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The effects of different systems of positive reinforcement on computer-based learning

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The effects of different systems of

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by

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CHAPTER 1. INTRODUCTION

Computers are used increasingly in schools today to enhance classroom learning (Kulik and Kulik, 1991). The capabilities of colors, graphics, and sounds of computers enable teachers to present students with vivid, exciting, alternative modes of instruction. One of the strong features of computers is that they can provide positive reinforcement for correct responses or for deriving correct solutions immediately (Hitchcock, 1984). According to B. F. Skinner, positive reinforcement hastens learning of certain behavior when it is presented following a situation (Skinner, 1953). Therefore, students might be shaped by providing positive reinforcement to the desired behavior.

Researches in the area of human behavior have demonstrated that positive reinforcement is a powerful skill for the management of learning (Gagné, 1970). Beneficial results of positive reinforcement also have been found in the wide range and variety of classroom circumstances (Holt, 1971; Lysakowski and Walberg, 1981; Gourgey, 1987). In computer-based learning (CBL), the role of positive reinforcement is to encourage the learner to continue behavior toward the learning objective and to indicate a learner when an objective has been reached (Godfery and Sterling, 1982). In other words, positive reinforcement provides incentives for the learner to be as successful as possible during the learning situation. Incentives in traditional forms of instruction involve praise, candies, or other special privileges. However, the introduction of the computers into the classroom has brought in unique incentives such as animated graphics, pleasant music, or the opportunity to play a computer game. While positive reinforcements are implemented in almost all computer-assisted instructional programs, the concern about what kind of positive reinforcement is the most effective at motivating learners has been raised by educators (Wager, 1984; Jaeger, 1988).

Forms and Schedules of Courseware Reinforcement

A necessary prelude to a discussion about computer-generated reinforcement is an explanation of the term of reinforcement. Reinforcement (sometimes informally called a reward) is the procedure of using a reward to increase the frequency of a behavior. The rewards obtained by learners during learning have the effect of strengthening the learning process (Harré and Lamb, 1983). Courseware reinforcement may be presented in several different forms. As Roblyer (1981) noted, "Positive reinforcement for correct answers is usually given either in the form of verbal feedback ("Good work, Morley"), or an animated creature of some kind." Poppen and Poppen (1988) proposed two types of reinforcement: sensory stimulation (e.g., sound, color and animation) and positive evaluation (e.g., "Good job"). Reinforcement can also be ranged from simple, such as "Correct," to complex, such as black and white monsters eating a castle (Jaeger, 1988).

Based upon a continuum of "obtrusiveness" researchers classify courseware reinforcement into three broad categories (Swenson and Anderson, 1982). The first category of reinforcement is called "passive," which only conveys information about the adequacy of a response. In this case, the user is notified about nothing else but the correctness of the response. The second category is called "active," which also provides information about response adequacy, but the reinforcement contains visual stimulation (e.g., happy face) or positive praise (e.g., "Great, Amy!"). The third category is called "interactive," which has all the properties of both passive and active reinforcement, plus one additional property: user participation. An example of this form is to grant the user an opportunity to play a video game after his/her correct response.

There are no specific rules regarding how to use different types of reinforcement. Nevertheless, with their experience and knowledge of the results of various studies, researchers have suggested guidelines in effectively utilizing reinforcement in computer software.

After reviewing much software, Williams and Williams (1985) found that sound, color, and graphics were the reinforcement used most often with preschool children, while programs for elementary level students used reinforcers such as graphics or verbal comments. At the high school level, reinforcers were more symbolic. According to learning theory and research, Jonassen and Hannum (1987) concluded that simple positive comments do not produce higher levels of motivation. Consequently, when designing computer software, the two authors suggested that constructive reinforcement that is both informative and interesting should be provided. On the contrary, some researchers found that students are not always interested in graphic or sound reinforcers for correct answers (Brebner et al, 1981; Jaeger, 1988). These findings imply that motivational learning environments can be created using rather simple techniques. However, despite the controversy, Chambers and Sprecher (1983) pointed out that the type of reinforcement must be geared to the students' needs and must be perceived by students as satisfying.

As to when selected forms of reinforcement should be given, different reinforcement schedules were proposed. Basically, there are two broad types of reinforcement schedule: continuous and intermittent (Favell, 1977). When reinforcement is given for every correct response, it is called "continuous reinforcement." However, on an intermittent schedule of reinforcement, reinforcement is given to the response only occasionally on an interval or ratio basis. Interval schedules are based on the time elapsed between reinforcers. Ratio schedules are based on the number of responses given between reinforcers. Moreover, the time elapse for an interval schedule and the number of responses given in a ratio schedule may be either constant or variable. That is, on a fixed schedule, a specific period of time or number of responses is required before the next response is reinforced. On a variable schedule, reinforcement occurs at any period of time or number of responses. This entails the four major intermittent schedules: fixed-interval, variable-interval, fixed-ratio, and variable-ratio.

The schedules are as important as the forms in providing reinforcement. To be most effective, some educators in the field of CBL suggested that positive reinforcement need not be provided for every correct response (Cohen, 1983; Hazen, 1985; Jonassen and Hannum, 1987). Sometimes, as Roblyer (1981) stated, "a word of praise after two or three short problems, or after every long problem, may be appropriate." Swenson and Anderson (1982), two educational researchers, recommended further that reinforcement should occur immediately after the desired response. Moreover, reinforcement should be given for every response whenever an individual is learning a new skill. As the individual obtains some experience, the reinforcement schedule should be "thinned out" (e.g., reinforce only at every fifth or tenth response).

The opinions of Chambers and Sprecher appear to be in agreement with Swenson and Andersons. In their book entitled "Computer-Assisted Instruction: Its Use in the Classroom," Chambers and Sprecher (1983) advocated that continuous reinforcement should be used until mastery is reached. Fixed and variable ratio is then utilized to maintain the acquired knowledge.

Need for the Study

Many educators consider that reinforcement is essential in designing certain types of courseware (Gagné et al., 1981; Swenson and Anderson, 1982; Jonassen and Hannum, 1987). Reinforcement is used in a manner that confirms the correct response and rewards the response, thereby increasing the probability of correct answers. However, as mentioned previously, the complexity of positive reinforcement varies widely. For example, a simple reinforcement system may have only either words of praise (e.g., "terrific") or a symbolic graph (such as a smiling face) presented when a correct response is given. On the other hand, a more complicated reinforcement system will show not only words of praise but also special graphic designs (e.g., moving pictures) as well as sound effects (Jaeger, 1988). Meanwhile, positive reinforcement systems may also differ from each other when they are presented. For instance, a continuous system presents a reinforcement whenever a correct response is found; a fixed-ratio system will present a reinforcement when a certain number of correct responses are achieved. Nevertheless, on a variable-ratio system, reinforcements occur on a random basis in which a reinforcement may or may not be presented when a correct response is given.

Apparently, the cost and energy involved in implementing these reinforcement systems are quite different. A complex design may cost much more than a less complicated one (Jaeger, 1988). In developing or choosing computer-based learning software, questions concerning the effectiveness of reinforcement systems may be raised: Will those simple designs do the job? Are complex patterns superior to simple ones? How will the effectiveness of different designs be affected by the schedules of reinforcement? Although more than thirty years of educational computing have passed, little is known about the effects of reinforcement (Jaeger, 1988). Empirical tests about the effectiveness of different systems of reinforcement on computer-based learning are needed.

Statement of the Problem

As portrayed in the previous section, further studies on the effects of different types of reinforcement using CBL are needed. The problem addressed in this study is to determine the effectiveness of three selected hierarchies of positive reinforcement stimuli (i.e., text, text with sound, and text with moving picture as well as sound effects) coupled with different presentation schedules (i.e., continuous, fixed-ratio, and variable-ratio) on CBL of the arithmetic concepts of addition for second graders.

Purpose of the Study

The purpose of the study is to investigate the effectiveness of various stimuli and schedules of positive reinforcement systems on computer-based learning (CBL) of the arithmetic concepts of addition. More specifically, the study is aimed at answering the following questions:

1. Are there any differences in student score means on addition problems when CBL is provided with different reinforcement stimuli, namely, text only, text with sound effects, and text with sound effects and moving pictures?

2. Are there any differences in student score means on addition problems when CBL is provided with different schedule of presentations (continuous, fixed-ratio, and variable-ratio) of reinforcements?

3. Are there any interaction effects between reinforcement stimulus and presentation schedule on student addition scores?

Hypotheses of the Study

To answer the above questions, the following hypotheses are formulated:

1. $H_o : \mu_{1.} = \mu_{2.} = \mu_{3.}$

   $H_1 : \mu_{j.} \neq \mu_{j'.}$ for some j and $j'(j \neq j')$

   where $\mu_{j.}$ and $\mu_{j'.}$ are mean scores on a test of the students who received different reinforcement stimuli.

2. $H_o : \mu_{.1} = \mu_{.2} = \mu_{.3}$

   $H_1 : \mu_{.k} \neq \mu_{.k'}$ for some k and k' $(k \neq k')$

   where $\mu_{.k}$ and $\mu_{.k'}$ are mean scores on a test of the students who received reinforcement stimuli on different time intervals.

3. $H_o : \mu_{jk} - \mu_{.k} - \mu_{j.} + \mu_{..} = 0$ for all j and k

   $H_1 : \mu_{jk} - \mu_{.k} - \mu_{j.} + \mu_{..} \neq 0$ for some j and k

where μ_{jk} is the interaction mean scores in each cell.

Delimitations of the Study

This research is delimited to inquire into the effects of different systems of positive reinforcement on an instructional program. Moreover, the sample of this research is selected from second graders of an elementary school in the state of Iowa. Therefore, any generalization made beyond this population cannot be assumed to be equally true.

Definition of Terms

1. Computer-based learning (CBL): All student learning that is related to the computer (Simonson and Thompson, 1990).

2. Courseware: Computer programs which direct the delivery of instruction (Futrell and Geisert, 1984).

3. Positive reinforcement: A rewarding stimulus given to the learner by the computer immediately following a correct response.

4. Continuous positive reinforcement: A specific kind of positive reinforcement presented following every correct response of the learner.

5. Fixed-ratio positive reinforcement: A specific kind of positive reinforcement presented following a fixed, or constant, number of responses.

6. Variable-ratio positive reinforcement: A specific kind of positive reinforcement presented following a random number of responses.

Procedure of the Study

The following is a list of tasks in completing the research:

1. Review the related literature.

2. Select the sample.

3. Develop the instructional computer programs.

4. Conduct a pilot test.

5. Revise the programs and the research design.

6. Implement the field test and collect data.

7. Analyze the data.

8. Write the dissertation.

Summary

This chapter introduced a study that investigated the effectiveness of various positive reinforcement systems. Reinforcement is used to confirm and reward the correct response, thereby inducing more correct responses. The complexity and schedule of courseware reinforcement vary widely. The cost and energy involved in implementing these reinforcement systems are also different. Thus, the problem of this study was to determine the effectiveness of three selected hierarchies of positive reinforcement stimuli coupled with different presentation schedules. The purpose of the study was to answer three questions: 1) Are there any differences in student score means on addition problems when CBL is provided with different reinforcement stimuli? 2) Are there any differences in student score means on addition problems when CBL is provided with different schedules of presentations of reinforcements? 3) Are there any interaction effects between reinforcement stimulus and presentation schedule on student addition scores? Three hypotheses were then formulated to answer these questions.

Finally, the delimitations of the study, definition of terms, and steps involved in the study were also shown in this chapter. Research related to the reinforcement systems on computer-based learning is discussed in Chapter Two.

CHAPTER 2. REVIEW OF THE LITERATURE

In this chapter, literature that pertains to the research topic in the areas of reinforcement and computer-based learning (CBL) will be presented and synthesized. The chapter begins with overviews of CBL and reinforcement. The guidelines in developing reinforcement on CBL are then presented. The effects of reinforcement on CBL are also discussed. A summary of the reviewed literature is included in the last portion of this chapter.

Overview of Computer-Based Learning (CBL)

Different terms have been used in the field of computing education. Computer-assisted instruction and computer-based instruction have been terms that frequently are used to describe computer use in education. Although computers have been used in education for many years, it is only recently that computer-based learning (CBL) has become a popular term. CBL gained popularity because of its featuring learning rather than instruction. More specifically, CBL is used to describe all student learning that is related to the computer, and thus provides a general term for all student/teacher computer work (Simonson and Thompson, 1990). The purpose of the section is to present an overview of CBL. In order to profit from the knowledge gained through successes and failures of the past, this section provides a description of the developmental stages in school computer use followed by types of computer software and categories for computer use in education.

The stages in developing educational computing in schools

Based on data gathered by Henry Becker at the John Hopkins Center for the Study of Technology and his own experience in working with dozens of schools, Lengel (1987) condensed the development of educational computing in schools into three stages: P, D, and T. These stages profile some common patterns in the ways that schools make use of the computer over time.

The first stage is called P Stage because the use of a computer is personal. At this stage, the utilization of computers centers around a single person who brings the first computer into the school. It is the person who knows how to use the machine. It is the person's interests that determine the machine's use; and it is the person's students who use it. Owing to lack of applications programs and the user-unfriendliness of the whole operation, programming usually is the major activity for the computer course during the P Stage.

As educators become more aware of the great potential of the computer in education, the school moves into the second stage, the D Stage. The "diffusion" of the computer into schools can be seen in this stage. Computer literacy is taught to all students. Students learn the parts of a computer and the difference between a bit and a byte. Schools buy quantities of instructional programs in all subject areas. The sales of educational software are sizable; and most of them are drill and practice (Dennis and Kansky, 1984; Lengel, 1987).

At the third stage, the T Stage, the computer is used as a "tool" to help and enhance the achievement of educational goals. For example, the data base is used not for showing how it works but for obtaining problem-solving skills via managing and analyzing certain information. It is at the T Stage that the curriculum has put the computer in its place.

Types of educational software

The developmental stages of computing education suggest that the computer should become a learning tool that we tailor it to fit the curriculum. How computers are used in classrooms depends on software, and traditionally educational uses of computers are classified by type of software. Though there are some variations, generally they include drill and practice, tutorial, simulation, problem-solving, tool, and computer-managed instruction (Simonson and Thompson, 1990).

Drill and practice software dominated early learning situations and is still offered today by programmers in a multiplicity of forms (Simonson and Thompson). The notion of drill and practice is that the students are provided with repeated exercises of a skill by the computer. The computer gives immediate feedback and keeps track of progress. It is usually designed as a supplement to regular instruction. Due to its adaptability to the curriculum and ease to be programmed, drill and practice programs had been overused in the past; currently uses of the program have been switched from lower educational objectives to higher-order ones. Thus, drill and practice can be used to allow the learner to practice applying grammar rules learned in the English class. When this is the case, drill questions take the form of a sentence with parts missing, or a statement without any punctuation marks. Through the activity, students' thinking and capabilities may be extended.

Computer tutorials are programs developed to act as tutors for students. In tutorials, the primary instruction on a topic is presented through an interactive teaching mode by information screens. In one sense, tutorial programs imitate teaching behavior (Simonson and Thompson, 1990). Virtually, any subject that can be taught by a teacher using a textbook can be taught using a computer and tutorial software. Computer tutorials offer an alternative way for student learning and help in achieving individualized instruction.

A simulation allows the users to develop a model of a real-life condition. Simulation software generally displays specific situations petitioned by the student, and then allows the student to input certain other conditions, and finally demonstrates the results. For instance, an economic simulation might involve the manipulation of interest rates, inflation, and unemployment to see what would happen to the economy. Simulation programs are valuable in education because they free students to operate various aspects of the model. In operating the model, students weigh various consequences, make certain decisions, and apply their learning; hence, simulations are considered to address higher-order educational objectives.

The problem-solving programs are similar to a simulation program because they all involve allowing students to manipulate variables and see the consequences of their actions. However, simulation programs model real-life condition, whereas problem-solving programs are a more general category which includes all the software for teaching problem-solving strategies. The main advantage in using problem-solving programs is that they give students an opportunity to form and test hypotheses and develop their critical thinking and problem-solving skills.

The use of computers as tools in teaching is rapidly becoming more widespread.

Tool software is computer software used as a tool to fulfill students' and teachers' tasks but do not designate the content of these tasks. The frequently used tools include data base, word processor, spreadsheet, telecommunication, and graphics software. Learning with tool software has the potential to develop a wide range of skills. The use of tool software often changes the role of the teacher from knowledge source to facilitator and question provider. In addition, using these programs will reduce some routine aspects of a task and enable teachers and students to focus on the higher-level cognitive skill.

With computer-managed instruction (CMI), computers can also help to manage the instructional process. Here the computer is used to keep students' records, diagnose and assess the learning process, report students' performance, communicate with parents, and, in general, to make classroom operation more efficient. Even if actual teaching is not done by a computer, much of the management of students' educational progress may be done by computerization. The use of CMI not only results in time-saving task-efficiency but also creates a positive role model for students; therefore, the outcomes can be very meaningful to the learner.

In the future, Dede (1987) points out that computers will be used as cognition enhancers designed to extend the cognitive power of human beings. Rather than classifying computer use by different type of software, Dede suggests that there will be three kinds of cognition enhancers: empowering environments, hypermedia, and microworlds. Empowering environments are those computer software used to handle the routine tasks while people are focusing in higher-order level activities. For example, a word processor with spelling checker, thesaurus, typing tutor, and graphics tool would be used to improve writing skills. Hypermedia is a framework for non-linear representation of symbols (text, graphics, image, software code) in the computer. It is a general tool which can be used as an externalized associational memory for an individual or an alternative representational system for a large, shared data base. Finally, a microworld is the cognitive enhancer which allows students to explore and manipulate artificial realities. Learning environments such as simulations and Logo language are examples of microworlds.

Categories for computer use

Thus far, types of educational software have been described; however, it is also helpful to see how computers can be used in educational settings. As Maddux (1984) has indicated, computer uses in schools can be Type I or Type II. Maddux refers to using the computer to learn in traditional ways (e.g., computer literacy and drill and practice uses) as Type I. Type II uses include using the computer in a new and better way to broaden and deepen learning. For example, computer programming is employed to improve cognitive skill rather than to train students as computer programmers. To give another example, students can use spreadsheets to create models for family budgets and use these models to test some financial hypotheses.

Taylor (1980), a famous computing educator, used the terms "tutor," "tool," and "tutee" when discussing using computers in learning process. As these terms imply, Taylor believed that the computer can be used as a tutor to teach students, as a tool for students to use, and as a tutee that students can teach. While the concepts of computer as tutor and tool had been presented in the previous section, the concept of computer as tutee needs more interpretation.

In the tutee mode, the traditional role of the computer in education is reversed.

Here, the student teaches the computer rather than the computer teaches the student. To teach the computer, the student must learn to talk to the computer in a language it understands. Though this process, "learners gain new insights into their own thinking." Thus, "the focus of education in the classroom can be shifted from end-product to process, from acquiring facts to manipulating and understanding them" (Taylor, 1980, p.4).

Thomas and Boysen (1984) suggested that the computer is a learning device rather than a teaching device; and the perspective of using the computer in schools should be student-centered rather than teacher-centered. Considering the state of the learner with respect to the learning material as the classifying variable, Thomas and Boysen proposed a taxonomy for instructional use of computers. At the lowest level of taxonomy, experiencing, the computer is used to get intuitive information or attitude for future learning. In this level, students use the programs that include a model of a concept, subject area, or attitude which can be manipulated by the students to get common experiences and references before formal instruction. In the informing level, the computer provides information for the students. The intention of this usage is to "map the student's existing knowledge and fill the gaps therein." The most common type of informing program is tutorial. After students obtain the information, the computer usage shifts to reinforcing level. In this level, the computer is used to fortify specific learning objectives. Drill and practice programs might be an example at this point. The next level of taxonomy, integrating, is the computer application which allows the students to apply previous learning to a new situation as well as to associate previously unconnected ideas. The highest level of the taxonomy is utilizing. Here the computer is used as a tool which allows students to incorporate the learned process in learning. Thus, the student may use a data base to illustrate and organize certain concepts of mammals.

Overview of Reinforcement

The preceding overview of computer-based learning indicates that the computer can be one of the important resources in classroom learning. However, many of the guiding principles of CBL were developed even before computers were ever used for learning. In the 1950s educators began by applying the techniques of behavior analysis through programmed instruction (Bell, 1985). Many authorities recognize B. F. Skinner as one of the forerunners of this movement (Gallo and Nenno, 1985). Skinner emphasized reinforcement and believed that the principles of stimulus and reward could produce learning. In fact, a major step in the development of ideas about reinforcement was Thorndike's Law of Effect (Magon and Garrison, 1972). Thorndike perceived that when connections between stimulus (i.e., an object or event) and response has been made, and the response is satisfactory, then the connection is reinforced. Skinner modified Thorndike's theories and claimed that reinforcement is a contingency which may be used to increase the frequency of the behavior. In Skinner's operant conditioning the presentation of the reinforcer is provided only for a "correct" response. In other words, reinforcement acts as a reward for a correct response of a learner. To get the reward again, the learner will try harder to perform the next response correctly. For better understanding, two topics concerning reinforcement theory are presented in the remainder of this section. They are: categories of reinforcement and effects of reinforcement on learning.

Categories of reinforcement

Reinforcement can be categorized in several ways: primary or secondary, positive or negative, continuous or partial (Woolfolk and McCune-Nicolich, 1984). Primary reinforcement is the stimulus which helps satisfy a primary drive, such as food, water, and freedom from pain. These stimuli are not learned, but are necessary for survival. Secondary reinforcement is a stimulus which has reinforcing properties through learning. As a general rule, secondary reinforcement obtains its reinforcing power through its association with other reinforcing stimuli. Money, for instance, cannot be drunk or eaten, but often becomes a primary reinforcement because it is frequently followed by some other stimulus, such as food. Positive reinforcement is a pleasant stimulus which, when presented following a response increases the strength of that response. For example, when a student answers a question correctly, and the teacher tells her that the answer was a good one, the student tends to answer the teacher's questions more frequently. On the other hand, a negative reinforcement involves increasing the strength of a response by removal of an unpleasant stimulus. Staying in the classroom while other classmates are at recess is an unpleasant feeling to many elementary schoolers. A response which removes the bad feelings, for instance, working quietly to get the teacher's approval to go outside, will tend to reoccur in the future.

Reinforcement can also be classified as continuous or partial. A continuous reinforcement gives reinforcement for every correct response. Partial reinforcement is sometimes called intermittent reinforcement since not every response is followed by a reinforcer. As stated in Chapter One, there are four types of interimittent reinforcement (Favell, 1977). Two are based on the elapse of some period of time. They are called interval schedules. The other two are ratio schedules, which are based on the number of responses made. The time span for an interval schedule and the number of responses given in a ratio schedule may be either fixed or variable. On a fixed schedule, a specific period of time or number of response is required before the next response is reinforced. Under a variable schedule, however, reinforcement occurs at any period of time or number of responses. This leads to the four major schedules of reinforcements, that is, fixed-interval, variable-interval, fixed-ratio, and variable-ratio.

Effects of reinforcement on learning

The effects of reinforcement has great impact on learning. General efficacy of reinforcement has been supported by many researchers (Page, 1958; Srivastava, 1968; Holt, 1971; Rose and Thornburg, 1984; Gourgey, 1987). Srivastava (1968), for example, investigated an empirical study which involved 48 subjects and three reinforcement conditions - primary, social, and control. All the subjects were given two tasks (Discrimination and Motor) and were allowed 40 trials for accomplishing the tasks. The results showed that primary and social reinforcement conditions were equally effective in increasing the rate of learning while there was no evidence of learning in control subjects. Furthermore, the interaction among Trial, Task, and Reinforcement was significant, which indicated that reinforcement is a necessary if not sufficient condition for learning.

Page (1958) conducted his experiment using more than 2,000 students in seventy-four high schools. Subjects were divided into three groups. One-third of the students received no comment on their tests, one-third received a stereotyped comment (e.g., excellent), and the final one-third received a personal comment freely written by teachers. On a later test, the free-comment group did best and the no-comment group did worst. Moreover, the greatest improvement was shown by the poorest students in the personalized comment group.

A study of the differences between two groups of children (four-year-old vs eight-year-old) in their level of mastery motivation and their need for approval was undertaken by Rose and Thornburg (1984). There were two conditions in the experiment: verbal reinforcement and nonreinforcement. The study found that younger children needed more reinforcement than did the older children, and all children spent more time in the reinforcement condition than in the nonreinforcement condition.

To provide a quantitative summary of recent research concerning the instructional effects of positive reinforcement, Lysakowski and Walberg (1981) used statistical techniques to synthesize studies within the research domain. Thirty-nine studies, which spanned a period of 20 years and contained 4,842 subjects, were included in the research. The major finding of their research was that the strong effects of positive reinforcement appeared constantly across grades (kindergarten through college), socioeconomic levels, race, private and public schools, and community types.

The power of reinforcement on learning has been demonstrated by researchers, as mentioned above. Educators view the effective use of positive reinforcement in the light of achieving school success (Homme et al., 1970). More specifically, reinforcement techniques help in the accomplishment of the instruction in the following three aspects:

1. Establishing and maintaining orderly student behavior, freeing the classroom from disruption and distraction, and aiming students toward productive learning activities.

2. Managing learning so as to instill in students a positive liking for learning and for the accomplishments to which it leads.

3. Capturing the interest of students in desirable problem-solving activities as sources of satisfaction for mastery of the intellectual skills involved in them (Gagné and Briggs, 1974, p.206).

The rules of using positive reinforcement are not entirely unknown to teachers or parents. More precisely, researchers suggested that reinforcement should be given immediately after the desired behavior; and should be provided frequently in small amounts (Homme et al., 1970). Furthermore, continuous reinforcement is important for the acquisition of new behavior, while intermittent reinforcement is suited for the maintenance of the behavior (Skinner, 1968). Finally, reinforcement is indeed a 'floater,' that is, it must be accommodated to the developmental, cultural, or social level of the learner (Forness, 1973).

Guidelines in Developing Reinforcement on CBL

Reinforcement following correct responses not only facilitates repetition of the correct responses but also conveys a motivational message to encourage continued responding (Carter, 1984). However, if used inappropriately, it could detract, rather than support, learning (Soulier, 1988). Guidelines in developing reinforcement on computer-based learning (CBL) are examined and presented in this section.

Based on two years of program design for English and writing lab usage, Hitchcock suggested that "all reinforcement should have some variety beyond "yes" and "no" and, at some later stage in the program, the reinforcement might be removed"

(Hitchcock, 1984, p.6). To help users determine what quality software is, Cohen (1983) proposed a set of criteria for the evaluation of microcomputer courseware. In terms of proper use of reinforcement, Cohen stated that reinforcement should not over-reinforce every correct response with elaborate praise such as "That's terrific! What an accomplishment!!" For young children or slow learners, plenty of positive reinforcement might be needed at first, but an option should be available to fade out the constant reinforcement.

After reviewing motivation models developed by researchers, Keller and Suzuki (1988) pointed out that reinforcement schedules should be used appropriately. In a tutorial, for instance, use reinforcement after every successful response, and after a series of correct responses in drill and practice programs. Moreover, reinforcement should be meaningful. Too much praise for a rather simple task could dilute the motivational benefits of other aspects of the program. Furthermore, reinforcement should be given for correct responses. Programs providing a more interesting graphic for a wrong response than for a correct response should be avoided. Finally, for some learners, it would be good to have an optional reward package. That is, the user may choose an animated character or a verbal reinforcement until the novelty effect wore off, then exclude it.

The effectiveness of reinforcement may be influenced by many variables. However, with more attentive considerations, it may provide the student with a reason to keep learning (Swenson and Anderson, 1982). Four of the most important variables concerning designing courseware reinforcement were identified by Swenson and Anderson. These variables are: timing, appropriateness, relevancy, and configuration.

The timing of reinforcement must be appropriate. It should occur immediately after the correct response. An improperly timed reinforcer could serve to reinforce something other than the correct response. Initially, reinforcement should be given for every correct response. As the individual gains some experience, the reinforcement schedule should be "thinned out."

Appropriateness of reinforcement is important. Age, experience level, and nature of disability of the user are examples of an important factor. Clearly, the same reinforcement that delights a child could insult an adult (Swenson and Anderson, 1982). Students who have used a variety of packages will expect to see more complicated graphics. Moreover, for disabled children, careful planning is needed. Autistic children, for instance, tend to over-react to certain kinds of visual display and to select irrelevant stimuli when learning.

Relevance of reinforcement is another important consideration. To teach concepts and skill in the most expedient way, reinforcement should be motivational as well as informational (Swenson and Anderson, 1982). In other words, reinforcement should be provided to add to the student's information about the subject matter. A spelling game, for example, might be the reinforcer following a lesson in English.

Configuration refers to the feedback routine as a whole and not just its reinforcement component. Thus, to minimize the negative aspects of feedback, feedback for an incorrect response should be as simple as possible.

Effects of Reinforcement on CBL

As stated earlier, there are several types of courseware, each functioning to achieve different educational purposes. Development of effective reinforcement is particularly applicable to the drill and practice and tutorial types of software. However, reinforcement is still relevant to other types of educational software. For example, after extracting a response from the learner, the simulation provides reinforcement in the form of a new condition. In computerized problem solving, to give another example, reinforcement occurs whenever the learner acquires a correct solution. In all case, the major purpose of reinforcement in CBL is that it can be used to motivate the student's learning (Godfery and Sterling, 1982). The idea has been confirmed by Malone (1981). Malone employed an arithmetic game to determine what makes games intrinsically motivating. In his experiment, Malone varied the reinforcement feature: arrows popping balloons, music, and verbal feedback. The primary finding was that though there were gender differences (boys liked arrows popping the balloons, whereas girls like the music), these elaborations did help to create a motivating environment.

Two more empirical studies, one with five-year-olds (Armour-Thomas et al., 1987) and the other with high school students (Salend and Santora, 1985), showed that implementing reinforcement in CBL resulted in positive outcomes. Armour-Thomas and others investigated the comparative effectiveness of different types of reinforcement on student's learning and retention of relational concepts. Subjects were eighty-nine kindergarten students from a low-income New York city school district. The authors presented three conditions of reinforcement (textual, symbolic, and pictorial) to the experimental groups, and no reinforcement to the control group. The results showed that the experimental groups performed significantly better than did the control group, although there were no significant differences in performance among the experimental groups.

Positive results were also reported by Salend and Santora. The two researchers used access to computer as a positive reinforcer to increase appropriate social behaviors. Five secondary-level handicapped students were involved in the study. The subjects were told that they could have access to the computer if all of them came to class prepared. The findings showed that access to the computers increased their preparedness for class. Moreover, students' educational skills, such as capitalization and decimals, as well as keyboarding skills, were enhanced through exposure to the computer.

Based on reviewed literature and his own experience, Waldrop (1984) further claimed that the success of Computer-Assisted Instruction (CAI) depended largely on the application of reinforcement to the technique. Waldrop identified three sources of reinforcement. First, the student is reinforced by the use of the machine itself. Second, the student is reinforced by the content and construction of the computer module. This type of reinforcement has two levels. The computer module holds the attention of the student until he/she masters the subject matter. Then the student is reinforced by the content of the subject itself. Finally, the learner is reinforced by external sources, such as peer group support and beliefs about the computer. Failure to access the reinforcement of responses through learning procedure would impair the effectiveness of a promising result.

Although reinforcement is critical in supporting computer-based learning, Jaeger (1988) conducted a research project with high school students and concluded that an overly complex reinforcement might not attract the user. Jaeger designed four programs which contained different structure of reinforcement, namely, plain text, sound, graphics, and sound/color graphics mix. After a period of time, Jaeger noticed that students were more interested in the demonstration of the correct answer rather than in reviewing the fancy reinforcement displayed by the computer.

While Jaeger observed that complicated graphics display and sound were a waste of time, Fejfar (1970) found that simple textual reinforcement did not actuate student achievement. In his study, Fejfar employed a computer-assisted instruction system to find out if the achievement of elementary students would be affected by social reinforcement in textual form. Subjects included twenty fourth graders chosen from the Indiana State University Laboratory School. Courseware was designed to present multiplication facts, judge the student response, and write a reinforcing statement. The reinforcement options available were praise, reproof, or both. The results showed that none of the textual reinforcements affected achievement.

Summary

In this chapter, an overview of CBL and reinforcement, guidelines for developing reinforcement, and the effects of reinforcement on CBL were presented. In this dissertation, computer-based learning is used to describe all student learning that is related to the computer. The reviewed literature showed that there are many computer uses in education including drill and practice, tutorial, simulation, problem-solving, tool and computer-managed instruction. Currently, schools purchase more computers and software and the uses in general are more thoughtful than at first. In the future, computers will be used as cognitive enhancers designed to extend the cognitive power of human beings.

The effects of reinforcement have great impact on learning. Research results have revealed that reinforcement is a necessary, if not sufficient, condition for learning. Furthermore, younger children need more reinforcement than do older children.

Generally speaking, positive reinforcement is the presentation of a pleasant stimulus to the learner following a correct response. Four types of reinforcement schedules have been identified by researchers. These schedules are known as interval and ratio schedules, and each may be administered in a fixed or variable manner.

When designing reinforcement systems on CBL, researchers pointed out that the writers should consider four aspects: timing, appropriateness, relevancy, and configuration. Moreover, reinforcement should extend beyond "yes" and "no" and, at the later stage in the CBL program, the reinforcement might be removed. Finally, researchers have confirmed the effectiveness of reinforcement on CBL. However, the agreement regarding the effectiveness of different designs of reinforcement on CBL has not been reached. Furthermore, the interaction between reinforcement design and reinforcement schedule has not been studied.

CHAPTER 3. METHODOLOGY

This chapter summarizes the research methodology of this study and is organized into seven sections: (1) Subjects, (2) Computer Software, (3) Instruments, (4) Instrument Reliability, (5) Research Design, (6) Research Procedure, and (7) Data Analysis.

Subjects

The subjects that participated in this study were students enrolled in the Gilbert Elementary School, Gilbert, Iowa, during the fall semester of 1991. Gilbert is a suburban school district located near Iowa State University. The Gilbert school district can be characterized as a diverse community. The residents consist of business and professional people, farmers, university and federal employees, and retired people. The average ACT score, during the 1990-1991 school year, was 22.9. Compared with the national average score (20.6) and the Iowa average score (21.8), the Gilbert students' score was above average (Gilbert Community School District, 1990).

Subjects were forty-five second-graders from two different classes. There were 15 males and 30 females. These children were seven or eight years of age and had some experiences with computers. During the experiment, subjects were randomly assigned to one of the nine groups in which each group ran a different computer program. One of the subjects withdrew after the pretest and did not receive the treatment and the posttest.

Computer Software

The language

To collect the necessary data for this research, nine computer programs were developed. These programs were designed on Apple II computers using SuperPILOT software. PILOT (Programmed Inquiry, Learning, or Teaching) is a CAI authoring language that is available on many microcomputers. The original PILOT system was developed in 1973 by John Starkweather at the University of California (Barker and Singh, 1983). It had only about eight instructions and was formulated in an attempt to help teachers produce courseware for their own needs after just a short period of learning the language.

Since that time, PILOT has been revised and extended many times. Today, SuperPILOT is more powerful than the original language. It allows teachers to write text on the screen, develop animated graphic and special character sets and create sound and music without much effort. Because of the availability of Apple computers in the elementary school where the research was conducted and the features that PILOT offered, the Apple SuperPILOT version was used for this research.

The programs

Nine computer programs were designed, all of which had identical instructional content. The objectives of the programs were:

1. to reinforce arithmetic concepts of addition to second graders.

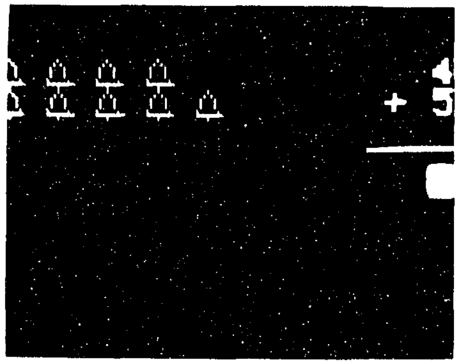
2. to help students apply addition techniques to problem situations.

3. to help students acquire confidence in doing addition.

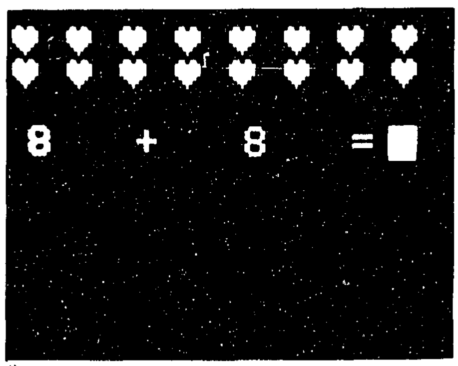
There were six levels in each program. The first level dealt with the addition of single-digit numbers arranged in vertical forms. The second level covered the same topic, except that the numbers were presented in horizontal forms. The third level was aimed at problem-solving types of questions. The fourth to sixth units dealt with the addition of two-digit numbers in vertical, horizontal, and problem-solving formats (Figures 3.1 and 3.2)

At the beginning of each program, a title page was presented followed by a five-problem placement test. Each problem was a sample drawn from each level, except for level six. Subjects were then branched to the specific level, according to their performance. For example, if a subject passed the first two questions and failed the third question, the computer would send the subject to level three. Likewise, if the subject passed all five questions, the computer would bring up level six to the subject. Hence, at least one unit of the program would be executed.

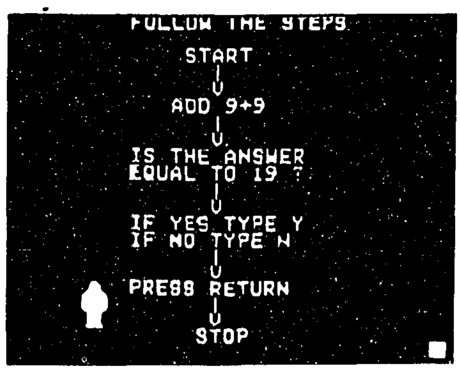
Each level consisted of four items. A specific reinforcement system designed for each group was presented following a correct response. A message such as "Try again, Please!" or a hint such as "Add the ones first, then add the tens" would be given after an incorrect response. The program permitted two attempts for each item. After two tries, the computer provided the correct answer and displayed the next item. The subjects had to answer all four items correctly before advancing to the next level; otherwise, the subject was requested to redo the level. If a subject completed the



Level 1

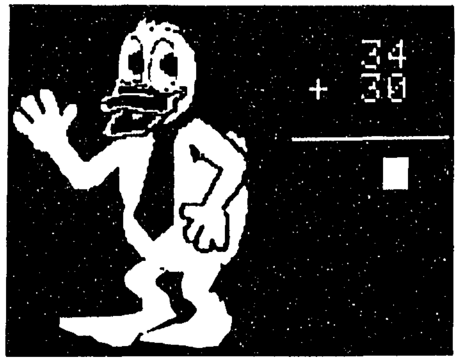


Level 2

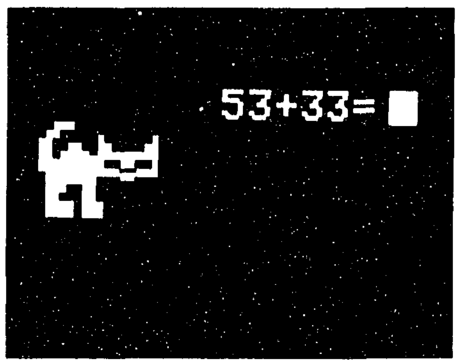


Level 3

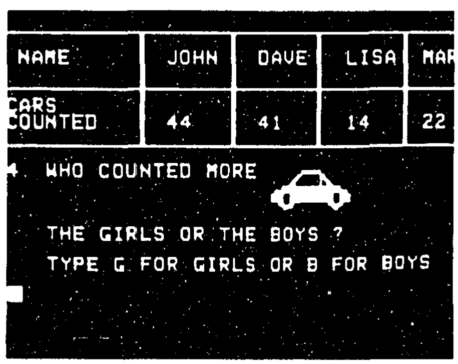
Figure 3.1: Screen design for level 1 to level 3



Level 4



Level 5



Level 6

Figure 3.2: Screen design for level 4 to level 6

highest level (level six), a congratulation statement was displayed and the program exited. See Figure 3.3 for a flowchart of the programs.

Although the programs had identical instructional content, each program had a different reinforcement system. These nine reinforcement systems were the combinations of two factors, reinforcement stimulus and schedule of presentation, as shown in Figure 3.4. In addition, a different stimulus was provided for each level. Figure 3.5 to Figure 3.10 illustrate the six stimuli.

Three reinforcement schedules were used in the programs. The continuous schedule was designed to give positive reinforcement following every correct response. The fixed-ratio schedule was programmed to give reinforcement following every two correct responses. Finally, the variable-ratio schedule was utilized to present reinforcement following a random number of correct responses. Hence, in the variable-ratio schedule, the presentation of reinforcement was unpredictable. Appendix A contains the program listing of the text, sound, and moving pictures for the variable-ratio schedule program.

Instruments

Prior to the experiment, subjects were provided with an identical paper-pencil pretest. At the conclusion of the experiment, subjects were again given a paper-pencil posttest.

The pretest was developed on the basis of related materials, such as curriculum guides, textbooks, the treatment programs, and consultation provided by the second-grade teachers and the research advisory committee. It was designed to measure the current achievement level of the subjects in the arithmetic concept of addition.

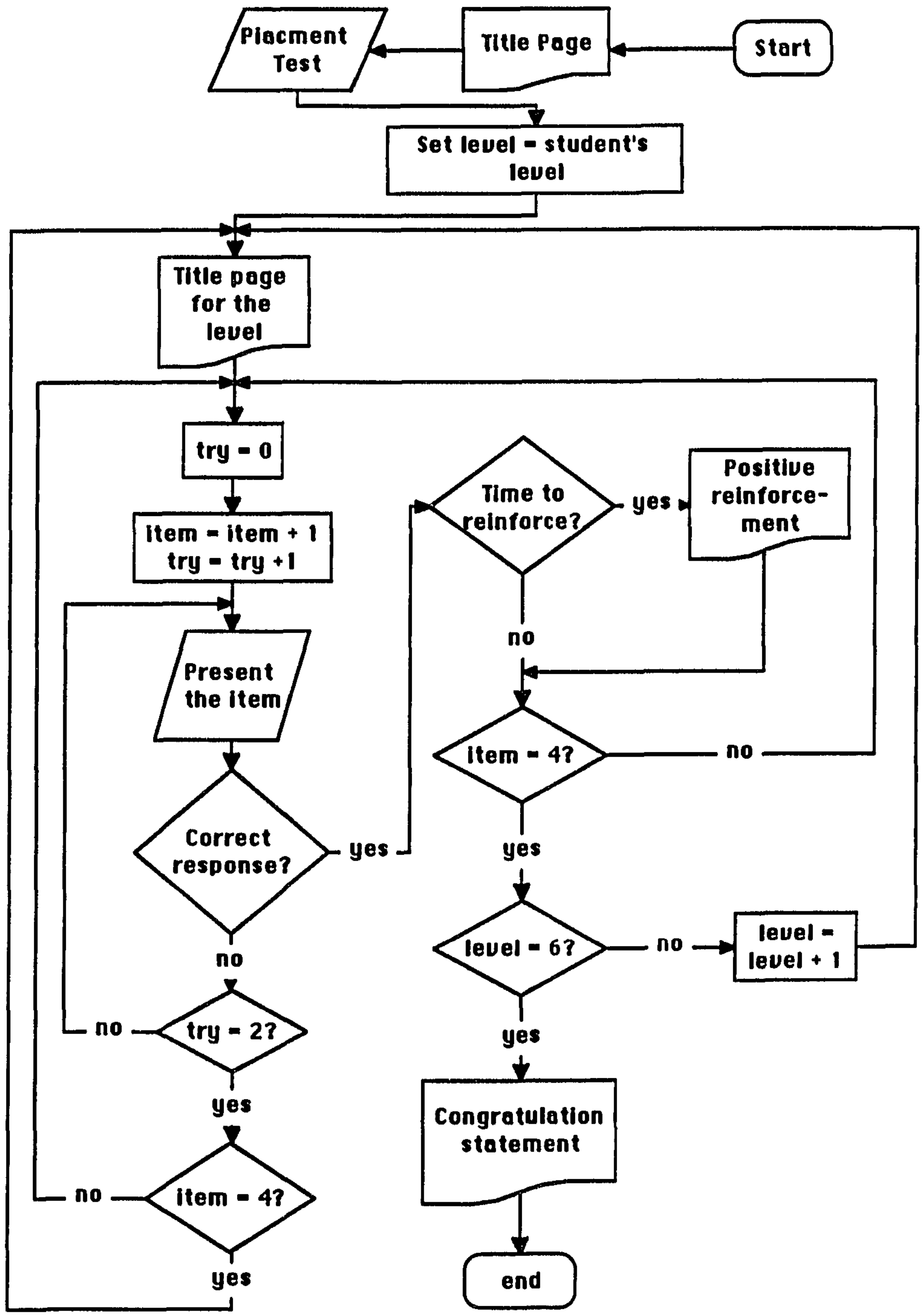


Figure 3.3: Flowchart of the programs

SCHEDULE	STIMULUS	Text	Text and sound	Text and sound and moving pictures
	Continuous			
	Fixed-ratio			
	Variable-ratio			

Figure 3.4: Factors of the research design

Text

Text and Sound

Text and Sound and Moving Pictures

Figure 3.5: Reinforcement stimuli for level one

Text

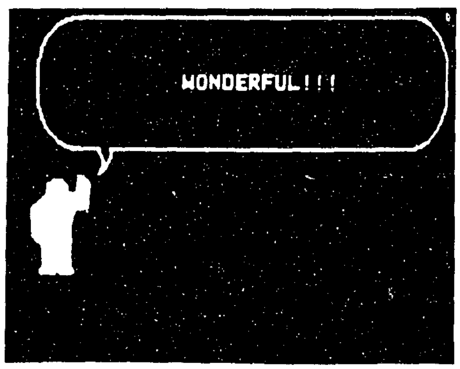
Text and Sound

Text and Sound and Moving Pictures

Figure 3.6: Reinforcement Stimuli for level two

Text

Text and Sound



Text and Sound and Moving Pictures

Figure 3.7: Reinforcement Stimuli for level three

Text

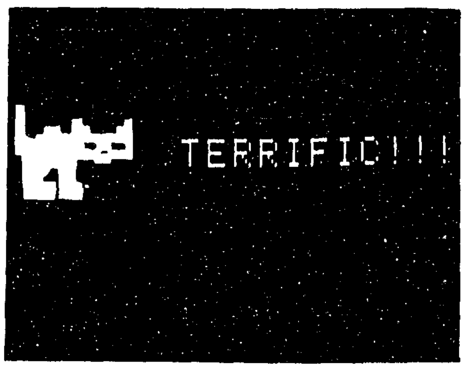
Text and Sound

Text and Sound and Moving Pictures

Figure 3.8: Reinforcement Stimuli for level four

Text

Text and Sound



Text and Sound and Moving Pictures

Figure 3.9: Reinforcement Stimuli for level five

Text

Text and Sound

Text and Sound and Moving Pictures

Figure 3.10: Reinforcement Stimuli for level six

The pretest scores served as the control variable when analysis of covariance was conducted. A sample of the pretest is included in Appendix E.

The posttest was used to determine if different reinforcement systems affected the students' final achievement of addition. The posttest was very similar to the pretest. Appendix F contains a sample of the posttest.

Instrument Reliability

To test the internal consistency of the instruments, the Statistical Package for the Social Sciences (SPSS-X) reliability sub-program and its procedure model alpha were used to calculate the Cronbach Alpha reliability coefficient for the instruments. As shown in Table 3.1, the alpha coefficients for the pretest and posttest were higher than .76, which were considered to be acceptable (Nunnally, 1978).

Table 3.1: Alpha coefficients for instruments

Test	Crobach's Alpha
Pretest	0.8117
Posttest	0.7695

Research Design

The design of the experiment was a fixed-effect model of two-factor factorial design. The two factors involved in the treatment were: stimulus of reinforcement and presentation schedule of reinforcement. Each factor consisted of three levels, as shown in Figure 3.4.

Research Procedure

Pilot test

After the development of preliminary instruments, a pilot test was conducted in the Ames Chinese School, Ames, Iowa, on October 6th, 1991. Nine second graders participated in the event. Children were asked to take the pretest, run the program and take the posttest. Several changes listed below were made after results of the pilot test were examined and the research advisory committee was consulted:

1. Appropriate rewording for instruments was provided.
2. A few slight alterations in the format of the instrument were made.
3. The placement tests were added to the programs.

Procedure

Permission was granted by the Principal of Gilbert Elementary School (Appendix C). The Iowa State University committee on the use of Human Subjects in Research reviewed this project and concluded that the rights and welfare of the subjects were protected (Appendix B). A letter explaining the project was sent to the parents of each subject. A copy of the letter can be found in Appendix D.

The research was implemented over a period of two weeks in the Fall semester of 1991. Forty-five children were randomly assigned to nine different groups. The children were told that they would be involved in a project to investigate the effectiveness of computer programs in learning arithmetic concepts of addition and that they would not be graded. On the first day of the study, all children were given an identical paper-pencil pretest. After that, each group of students worked on a specific program which contained one of the reinforcement systems as discussed previously.

The classrooms where the study was conducted were equipped with one computer in each room. However, two more computers provided by the department of Curriculum and Instruction of Iowa State University were added during the experiment. Subjects were arranged to work on the computers in turn due to the lack of a computer for each student. During the experiment, each child ran the program three times. Each time trial was limited to 40 minutes. After all the students had completed one trial, the cycle started over again until each student had access to the program for three trials.

All the computer activities took place during the students' regular classroom sessions. No additional time was required. During the first trial, students were supervised and shown how to boot and load the program by the researcher. Students worked alone at the other two times. A timer was installed beside the computer. Subjects were asked to set the timer to zero when they started, and to mark down the date and time on the timer when they stopped the program. The total time spent on the computer for each child was then calculated by the researcher.

As soon as a student ran the program three times, the student was given the posttest. After the experiment was over, copies of the programs were donated to the classes; thus, the children who did not participate in the study had the opportunity to use the programs.

Data Analysis

Data collected from the research were analyzed using the t-test, and analysis of covariance to determine if different treatments affect student achievement. The level of significance was set at 0.05. Descriptive statistics including frequencies, means, and standard deviations were used to describe the distribution of the data. To predict the posttest score and time spent on the computer for the one subject that withdrew following the pretest, a regression model was used. This model utilized the pretest score, the stimulus level, and schedule level as predictors of both the posttest and time dependent variables.

Summary

This chapter summarized the research procedures and methods used in this study. Forty-five subjects were involved in the study. To collect the necessary data for this research, nine computer programs written on Apple II computers using SuperPILOT software were designed to reinforce the arithmetic concepts of addition for second graders. Although the programs had identical instructional content, each program had a different reinforcement system. These nine reinforcement systems were the combinations of the two factors, reinforcement stimulus and schedule of presentation.

Subjects were randomly assigned to nine different groups in which each group ran a different program. Prior to the experiment, subjects received an identical paper-pencil pretest. At the conclusion of the experiment, subjects were given a paper-pencil posttest. The alpha coefficients for the pretest and posttest were higher than 0.76, which were considered to be acceptable. Descriptive statistics, t-test, and analysis of covariance were applied to analyze the collected data.

CHAPTER 4. RESULTS

This chapter presents the results of this study. In the first section, results related to research hypotheses are reported. The second section provides the results of the additional data analyses. The final section of this chapter summarizes the study results.

The computer programs used to analyze the data were the Statistical Package for the Social Sciences (SPSS-X) and Statistics and Measurement Programs Learning Environment (SAMPLE). The test utilized to evaluate the research hypotheses was the analysis of covariance.

Results Related to Research Hypotheses

Hypothesis 1

It was hypothesized that there is no significant difference in student score means on addition problems when students are provided with different reinforcement stimuli, namely, text only, text with sound effects, and text with sound effects and moving pictures. In statistical form,

$$H_o : \mu_{1.} = \mu_{2.} = \mu_{3.}$$

$$H_1 : \mu_{j.} \neq \mu_{j'.} \text{ for some } j \text{ and } j'(j \neq j')$$

where $\mu_{j.}$ and $\mu_{j'.}$ are mean scores on a test of the students who received different reinforcement stimuli.

Scores on the posttest ranged from 7 to 20, out of 20 possible points. The posttest means and standard deviations for the nine groups are shown in Table 4.1. A two-way analysis of covariance was conducted to determine if any statistically significant difference among the scores of the nine groups existed. The posttest scores served as the criterion variable and the pretest scores were used as the control variable. After statistically regressing the nine groups on the control measure, the statistical significance of the difference among the nine groups was tested. The results showed that the pretest was found to be a significant covariate, with $p<0.000$ (Table 4.2); however, the stimulus effect was not statistically significant ($F=2.27$, $p<0.119$). Thus, after controlling for the pretest, different reinforcement stimuli did not affect student score means on addition problems.

Hypothesis 2

It was hypothesized that there is no significant difference in student score means on addition problems when students are provided with different schedules (continuous, fixed-ratio, and variable-ratio) of reinforcement. In statistical form,

$$H_o : \mu_{\cdot 1} = \mu_{\cdot 2} = \mu_{\cdot 3}$$

$$H_1 : \mu_{\cdot k} \neq \mu_{\cdot k'} \text{ for some } k \text{ and } k' \ (k \neq k')$$

where $\mu_{\cdot k}$ and $\mu_{\cdot k'}$ are mean scores on a test of the students who received reinforcement stimuli on different time intervals.

The results from the two-way analysis of covariance showed that the schedule effect was found to be non-significant, $p<0.804$. Hypothesis 2 failed to be rejected at 0.05 level (Table 4.2). Hence, different reinforcement schedules did not affect student score means on addition problems, when initial differences among the nine experimental groups have been adjusted with respect to the pretest scores.

Hypothesis 3

It was hypothesized that there is no interaction between reinforcement stimulus and presentation schedule on student addition scores. In statistical form,

$$H_o : \mu_{jk} - \mu_{.k} - \mu_{j.} + \mu_{..} = 0 \text{ for all } j \text{ and } k$$

$$H_1 : \mu_{jk} - \mu_{.k} - \mu_{j.} + \mu_{..} \neq 0 \text{ for some } j \text{ and } k$$

where μ_{jk} is the interaction mean scores in each cell.

Again, the results from the two-way analysis of covariance indicated that the difference was not statistically significant, with $p<0.83$ (Table 4.2). Hypothesis 3 was not rejected at 0.05 level. Therefore, after controlling for the pretest, no significant interaction between reinforcement stimulus and presentation schedule on student addition scores was found.

Additional Analyses

In addition to the results of hypotheses testing, additional results including two-way analysis of covariance for testing differences among normalized posttest scores, one-way analysis of variance for comparing the nine groups' pretest scores, paired t-test for pretest scores versus posttest scores, and two-way analysis of covariance for collating subjects' time spent on computers are reported in this section.

Analysis of covariance for normalized posttest scores

In analyzing the differences among the nine groups on the posttest, it was noted that the distribution of the scores was skewed to the left. Since two-way analysis of covariance assumes normality of the dependent variable errors, the results of the above analysis of covariance cannot be considered appropriate. For this reason, normalized posttest scores were used instead of the raw scores. The analysis of covariance was performed again. The p-values obtained for the covariate, stimulus, schedule, and the interaction effect were 0.001, 0.140, 0.647, and 0.820, respectively. Once more, the covariate was found to be significant while both of the two main effects as well as the interaction effect were found to be non-significant. The results of using the normalized data were consistent with the raw data. The three research hypotheses were not rejected. See Table 4.3 for the details of the comparisons.

Comparison of pretest mean scores

Pretest scores of the subjects ranged from 7 to 20, out of 20 possible points. The pretest mean scores and standard deviations for the nine groups are shown in Table 4.4. An analysis of variance was conducted to compare the results of the nine experimental groups on the pretest scores. The calculated F-value was 0.736, with p-value of 0.659 (Table 4.5). Therefore, there were no significant differences among the nine groups on the pretest. The nine experimental groups were considered equivalent at the outset of this study.

Comparison of pretest and posttest means for the total group

To see if there was any significant difference between pre- and postscores when students were provided with different reinforcement systems, a paired t-test was conducted. The calculated t-value was 4.84, with p-value of 0.000 (Table 4.6). This indicates that subjects performed significantly better on the posttest than on the pretest.

Comparison of time spent on computers

As stated in Chapter 3, the total time spent on computers for each group was calculated by the researcher. The amount of time spent on computers ranged from 14 minutes to 120 minutes. Table 4.7 shows the average of time spent on computers for each group.

The question was asked whether or not different positive reinforcement systems would affect the time spent on computers after controlling for pretest scores. A two-way analysis of covariance was employed to answer this question. The results of the two-way analysis of covariance indicated that both the covariate and the stimulus effect were found to be significant, with $p<0.000$ and $p<0.05$, respectively; whereas the schedule effect and the interaction were found to be non-significant, with $p<0.628$ and $p<0.937$ respectively (Table 4.8). The pretest was again found to be a significant predictor. Moreover, after controlling for the pretest, different reinforcement stimuli (text, text and sound, text and sound and moving picture) affected students' average time spent on computers. However, the amount of time spent on computers was not affected by different schedules when initial differences among the experimental groups have been adjusted with respect to the pretest. Finally, there was no interaction effect between the reinforcement stimulus and presentation schedule on students' average time spent on computers.

Because of the distribution of the time spent on computers was found to be uniform rather than normally distributed, the raw data were then transformed to normalized Z scores and analysis of covariance was conducted once more. The results of using the normalized data were the same as using the raw data, except that the stimulus effect was found non-significant in the later analysis, with $p<0.116$ (Table 4.9). Therefore, neither stimulus nor schedule affected the time spent on computers. Moreover, the interaction between reinforcement stimulus and schedule was still not found.

Table 4.1: Means and standard deviations of the posttest

Group	Reinforcement System	N	Mean	SD
1	T[a]with continuous schedule	5	17.2	0.84
2	T & S[b]with continuous schedule	5	15.4	5.23
3	T & S & M[c]with continuous schedule	5	17.6	2.07
4	T with fixed-ratio schedule	5	16.2	2.59
5	T & S with fixed-ratio schedule	5	17.8	1.48
6	T & S & M with fixed-ratio schedule	5	18.2	1.79
7	T with variable-ratio schedule	5	18.4	2.07
8	T & S with variable-ratio schedule	5	16.2	4.32
9	T & S & M with variable-ratio schedule	5	18.2	2.39

[a]T = text.
[b]T & S = text & sound.
[c]T & S & M = text & sound & moving pictures.

Table 4.2: Analysis of covariance for null hypotheses

Source	SS	DF	MS	F	Sig. of F
Covariates					
Pretest	99.56	1	99.56	17.30	0.000**[a]
Main Effects					
Stimulus	26.08	2	13.04	2.27	0.119
Schedule	2.53	2	1.26	0.22	0.804
Interaction	8.62	4	2.15	0.37	0.825
Residual	201.38	35	5.75		
Total	338.31	44	7.69		

[a]Significant at 0.001 level.

Table 4.3: Analysis of covariance for normalized posttest

Source	SS	DF	MS	F	Sig. of F
Covariates					
Pretest	9.80	1	9.80	14.63	0.001**[a]
Main Effects					
Stimulus	2.79	2	1.39	2.08	0.140
Schedule	0.59	2	0.29	0.44	0.647
Interaction	1.02	4	0.25	0.38	0.820
Residual	23.45	35	0.67		
Total	37.69	44	0.86		

[a]Significant at 0.001 level.

Table 4.4: Means and standard deviations of the pretest

Group	Reinforcement System	N	Mean	SD
1	T[a] with continuous schedule	5	15.2	3.56
2	T & S[b] with continuous schedule	5	13.8	4.09
3	T & S & M[c] with continuous schedule	5	14.4	3.05
4	T with fixed-ratio schedule	5	14.6	4.72
5	T & S with fixed-ratio schedule	5	17.6	2.70
6	T & S & M with fixed-ratio schedule	5	13.0	2.55
7	T with variable-ratio schedule	5	16.6	3.21
8	T & S with variable-ratio schedule	5	13.6	4.62
9	T & S & M with variable-ratio schedule	5	15.4	5.13

[a] T = text.
[b] T & S = text & sound.
[c] T & S & M = text & sound & moving pictures.

Table 4.5: Analysis of variance for pretest by group

Source	SS	DF	MS	F	Prob.
Between Groups	86.84	8	10.86	0.736	0.659
Within Groups	530.80	36	14.74		
Total	617.64	44			

Table 4.6: Paired t-test for pretest versus posttest scores

variable	N	Mean	SD	T	2-tailed Prob.
Posttest		17.2	2.78		
	45			4.84	0.000**[a]
Pretest		14.9	3.75		

[a]Significant at .001 level.

Table 4.7: Average of time spent on computer for each group (in minutes)

Group	Reinforcement System	Time
1	T[a]with continuous schedule	34.0
2	T and S[b]with continuous schedule	77.4
3	T & S & M[c]with continuous schedule	61.4
4	T with fixed-ratio schedule	48.2
5	T & S with fixed-ratio schedule	48.2
6	T & S & M with Fixed-ratio schedule	61.4
7	T with variable-ratio schedule	36.6
8	T & S with variable-ratio schedule	83.6
9	T & S & M with variable-ratio schedule	64.8

[a]T = text.
[b]T and S = text & sound.
[c]T & S & M = text & sound & moving pictures.

Table 4.8: Analysis of covariance for time by schedule and stimulus

Source	SS	DF	MS	F	Sig. of F
Covariates					
Pretest	20253.19	1	20253.19	23.12	0.000**[a]
Main Effects					
Stimulus	5720.89	2	2860.45	3.27	0.050*[b]
Schedule	826.25	2	413.12	0.47	0.628
Interaction	696.55	4	174.14	0.20	0.937
Residual	30665.90	35	876.17		
Total	58175.24	44	1322.17		

[a]Significant at 0.001 level.
[b]Significant at 0.05 level.

Table 4.9: Analysis of covariance for normalized time spent on computers

Source	SS	DF	MS	F	Sig. of F
Covariates					
Pretest	13.68	1	13.68	21.68	0.001**[a]
Main Effects					
Stimulus	2.89	2	1.45	2.29	0.116
Schedule	0.55	2	0.28	0.44	0.651
Interaction	0.73	4	0.18	0.29	0.883
Residual	22.08	35	0.63		
Total	39.92	44	0.91		

[a]Significant at 0.001 level.

Summary

In this chapter, results of the study were presented. An analysis of variance was conducted to compare the nine experimental groups on the pretest scores. The results demonstrated that the nine experimental groups were equivalent at the outset of this study. Testing of the hypotheses revealed that the three hypotheses failed to be rejected at the 0.05 level. A paired t-test was used to determine if statistically significant differences between the pretest and the posttest existed. The results showed that subjects performed much better on the posttest than on the pretest. Additional analyses for comparing subjects' average time spent on computers were also performed. The results indicated that different reinforcement systems did not affect students' average time spent on computers.

CHAPTER 5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The foregoing chapters presented the background, related literature, methodology, and results of the research. This chapter is to summarize the research findings from the preceding chapters, to draw conclusions based on the findings, and to provide some recommendations for further studies.

Summary of the Study

The purpose of the study was to investigate the effectiveness of various stimuli and schedules of positive reinforcement systems on computer-based learning of the arithmetic concepts of addition. To fulfill the purpose, nine computer programs were developed on Apple II computers using SuperPILOT software. All programs had identical instructional content which was to reinforce the concepts of addition for second graders. Although the programs had identical instructional content, each program had a different reinforcement system. These nine reinforcement systems were the combinations of two factors, reinforcement stimulus and schedule of presentation.

The subjects used in this study were forty-five second-graders. There were fifteen males and thirty females. These children were seven or eight years of age and had some experience with computers. During the experiment, subjects were randomly

STIMULUS

SCHEDULE	Text	Text and sound	Text and sound and moving pictures
Continuous	Group 1 N = 5	Group 2 N = 5	Group 3 N = 5
Fixed-ratio	Group 4 N = 5	Group 5 N = 5	Group 6 N = 5
Variable-ratio	Group 7 N = 5	Group 8 N = 5	Group 9 N = 5

Figure 5.1: Group assignment for the research

assigned to one of the nine groups in which each group ran a different computer program (Figure 5.1).

The experiment was a fixed-effect two-factor factorial design. Prior to the experiment, subjects were provided with an identical paper-pencil pretest. At the conclusion of the experiment, subjects were again given a paper-pencil posttest. The experiment was implemented over a period of two weeks in the Fall semester of 1991. The alpha reliability coefficients for the pretest and posttest were higher than 0.76, which were considered to be acçeptable. An analysis of variance was conducted to compare the nine experimental groups on the pretest scores. The results demonstrated that the nine experimental groups were equivalent at the outset of this study. Differences among treatment group means were tested for statistical significance by two-way analysis of covariance. The results revealed that the three research hypotheses failed to be rejected at 0.05 level (Table 5.1). A paired t-test was then used to determine if statistically significant differences between the pretest and the posttest existed. The results showed that subjects performed significantly better on the posttest than on the pretest. The conclusions and discussions related to the testing results are summarized and presented in the following sections.

Table 5.1: Summary of ANCOVA results

	F	Sig. of F
Stimulus effect	2.27	0.119
Schedule effect	0.22	0.804
Interaction	0.37	0.825

Conclusions

Based on the data analyses, the conclusions of this study were:

1. Different reinforcement stimuli did not affect student score means on addition problems.

2. Different reinforcement schedules did not affect student score means on addition problems.

3. There was no significant interaction between reinforcement stimulus and presentation schedule on student addition scores.

4. Subjets performed much better on the posttest than on the pretest.

Discussion

The present study was to examine factors that affect students' arithmetic achievement of addition in computer-based learning environment. One factor that was manipulated in the experiment was giving children different forms of courseware reinforcement (i.e., reinforcement stimuli). An assumption regarding this matter is that a complex positive reinforcement would be better in catching students' interest, thus leading to better learning than a simpler one. Some courseware developers, however, believe that reinforcement that includes "flashing lights and whistling bells" is a waste of time and slows the pace of the program for fast learners (Soulier, 1988).

Another factor that may affect students' achievement is the schedule of presentation of reinforcement. Some students may expect to receive reward whenever they answer correctly. Nevertheless, others may feel that positive reinforcements are all right once in a while but tedious if appearing following every correct response. In addition, the effectiveness of courseware reinforcement may largely depend on the administration schedule of reinforcement interacting with reinforcement stimuli.

The results from manipulating these two factors showed that the stimulus effect and schedule effect, as well as the interaction effect, were statistically non-significant. Four convincing explanations may account for the findings in the study. First, the group size of this study (five students in each group), although sufficient for adequate analysis (Ott, 1984), may have not been large enough in detecting significant differences. Secondly, the time dedicated in the experiment might have been relatively too short (two weeks) to produce different treatment effects. A study of greater duration might have generated different results. Thirdly, the distribution of the posttest scores of the study was skewed to the left. This might reflect the "ceiling" effect of the test. A student could only obtain a maximum of 20 points on the posttest. The subjects obtained a mean of 17.2 which clearly approaches the maximum score and limits the possible variation. Lastly, perhaps a more inspiring explanation, the CBL environment is very different from a traditional classroom. As Waldrop (1984) pointed out, one of the sources of reinforcement is the use of the computer itself. Students involved in using computers might have been intrinsically motivated. The effects of the courseware reinforcement in this study possibly had been overshadowed by the use of the computer.

While there were no significant differences among the nine different reinforcement systems, there was a difference between the pretest and the posttest scores (Figure 5.2). It was found that subjects performed significantly better on the posttest than on the pretest, $p<.000$. This supports the finding of Kearsley et al. (1983), Bennett (1991), and Kulik and Kulik (1991). Generally, a computer-based learning environment can be effective in improving student achievement. Moreover, the results of this research should be important to software designers. Due to the relative ease of creating animation and sound, it is very attractive to incorporate spectacular reinforcement in CBL programs. The results of this study reinforce the idea that software designers should emphasize the quality of instructional sequences rather than entertaining the student (Jaeger, 1988; Surber and Leeder, 1988; Wager and Wager, 1985; Thorkildsen and Reid, 1989).

With regard to the reinforcement schedule, the results of this study disclose that providing reinforcement for every correct response will probably achieve as significant reinforcement effects as for a random number of responses. This result is in agreement with Chamber and Sprechers' conclusions (Chamber and Sprecher, 1983). Therefore, in terms of economy and convenience, it is fair to suggest that positive reinforcement need not be provided for every correct response (Cohen 1983; Hazen, 1985; Jonassen and Hannum, 1987) and it is appropriate when reinforcement is provided only occasionally (Roblyer, 1981).

Though due to the lack of a control group, the strong conclusion cannot be assured, the subjects' significant improvement from pre- to posttest also supports the belief that drill and practice programs can be used to achieve certain kind of educational purpose (Gagné, 1982). In the experiment, nine drill and practice programs were utilized . According to Gagné, if viewed as a part of cognitive learning theory, drill and practice brings basic skills (such as arithmetic) to a state of automaticity. Since basic skills are used frequently and since working memory has a limited capacity, drill and practice permits such skills to be retrieved and used very quickly. Once more, the subjects' advancement confirms that computerized drill and practice has potential for making significant contribution to the learning process.

In summary, this study investigated the effects of different systems of positive reinforcement on computer-based learning. No differences were found among reinforcement conditions, although subjects performed significantly better on the posttest than on the pretest. Despite the findings of this study, there remains an indication that children may react differently to different types of reinforcement, as is also suggested in the research literature (Forness, 1973; Chamber and Sprecher, 1983;

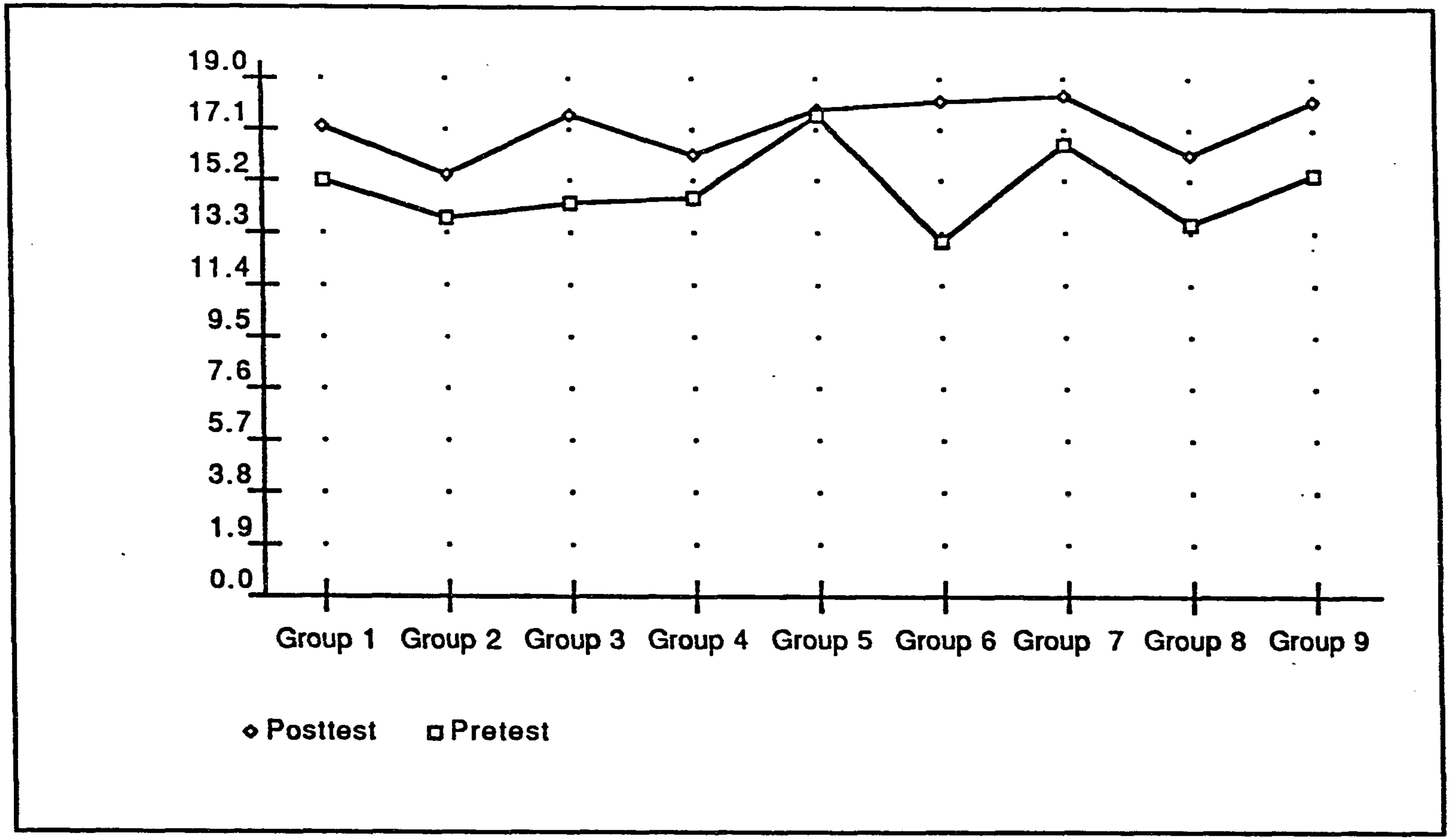


Figure 5.2: Pretest and posttest scores for the nine groups

Swenson and Anderson, 1982; Rose and Thornburg, 1984). Doubtless, more extensive empirical study should be employed to assess the effect of courseware reinforcement. Such studies may produce different results that are not easily assessed in non-laboratory settings or manipulated by traditional learning environments.

Recommendations

Based upon the results of this study, the following recommendations are proposed:

1. It is recommended that future studies use tests which contain more difficult items that can measure a greater range of the performance of high-achieving subjects.

2. An expanded study with a larger number of subjects and over a longer period of time can be done to strengthen the validity and increase the generalizability of the results.

3. Future research to replicate the findings on other concepts, grade levels, and subjects areas is recommended. For example, it would be relevant to examine the effects of positive reinforcement on computer-based learning on the classifying concepts for the kindergarteners.

4. A similar study is recommended by including other types of reinforcement such as different ways in presenting a student's score to emphasize his/her accomplishments coupled with other schedules of reinforcement (e.g., fixed-interval, variable-interval, as well as mixed schedule).

5. The nature of the software utilized in the study is drill and practice. Different types of software, such as a tutorial or simulation, may be used in further research.

6. Further research is recommended to study the effects of different systems of reinforcement by combining strong positive reinforcement for a correct response and mild punishment for an incorrect response.

7. It is recommended that a research in finding the differences between the effects of an optional and the non-optional reward package on the student's performance be undertaken.

Summary

This chapter summarized the results of the foregoing chapters. In addition, a brief discussion of the findings, together with the conclusions, were provided. The present study investigated the effects of different systems of positive reinforcement on computer-based learning. No differences were found among reinforcement conditions, although subjects performed significantly better on the posttest than on the pretest. The no difference in system of reinforcement suggests that the effects of the courseware reinforcement in this study possibly had been overshadowed by the use of the computer. Moreover, the implications for education are threefold: 1) software designers should emphasize the quality of instructional content rather than entertaining the student; 2) positive reinforcement need not be provided for every correct response; and 3) computer-based learning of this type may be effective in improving student achievement. Finally, the recommendations reflect what has been learned so far. Obviously, more extensive empirical study about the effectiveness of different systems of courseware reinforcement are needed.

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To whom named and unnamed, I thank you.

APPENDIX A. PROGRAM LISTING

```
R:**********************************
 :*                                *
 :*  PROGRAM NAME: ADD 1-2-3       *
 :*                                *
 :*  AUTHOR: YANG MEI-HSUEH        *
 :*                                *
 :*  TEXT + SOUND + PICTURE        *
 :*  ---- VARIABLE RATIO           *
 :*                                *
 :*  FALL, 1991                    *
 :*                                *
 :**********************************

(0001) *TITLE                        (0001-0010 Present title
(0002) PR:U                           page and music of the
(0003) GX:WELCOME!                    program.)
(0004) SX:BEETH
(0005) G:M130,423
(0006) TS:S2
(0007) T:WELCOME TO
(0008) TS:G10,22
(0009) T:ADD 1-2-3
(0010) TS:S1

(0011) *DIM                          (011-028 Set dimensions of
(0012) D:L1$(2);L2$(2);L7$(5)         the program.)
(0013) D:M1$(15);M2$(15);M3$(15);
       :M4$(15);M5$(15);M6$(15);M7$(15);M8$(15)
(0014) D:M9$(15)
(0015) D:P1$(5);P2$(5);P3$(5);P4$(5);P5$(5)
(0016) D:P6$(5)
(0017) C:P1$="JOHN";P2$="DAVE";P3$="LISA"
(0018) C:P4$="MARY";P5$="GIRLS";P6$="BOYS"
(0019) C:L1$="E";L2$=" ";L7$="A"
(0020) C:M1$=" a / bc/ de"
(0021) C:M2$=" fg/ hi/ jk"
(0022) C:M3$=" lm/ nop/ qr"
(0023) C:M4$="DAG/EBH/FC"
(0024) C:M5$="XAG/YBH/FC"
(0025) C:M6$="KAU/IB/FC"
```

```
(0026) C:M7$="DAS/EBT/FC"
(0027) C:M8$="    /    /    "
(0028) C:M9$="DA./EB /FC"

(0029) *TEST1                  (0029-0045 Placement
(0030) C:A=RND(7)+1             test one. If the answer
(0031) C:B=RND(7)+1             correct, present next
(0032) C:C=A+B                  problem; otherwise,
(0033) G:ES                     branch to level one.)
(0034) TS:S2;G10,5
(0035) T:   #A
(0036) TS:G10,7
(0037) T:+ #B
(0038) TS:G9,9
(0039) T:_____
(0040) TS(C>9):G13,12
(0041) TS(C<=9):G14,12
(0042) A:#D
(0043) TS:S1
(0044) J(D=C):TEST2
(0045) J(D<>C):LEV1

(0046) *TEST2                  (0046-0058 Placement
(0047) C:A=RND(9)+1             test two. If the answer
(0048) C:B=RND(9)+1             correct, present next
(0049) C:C=A+B                  problem; otherwise,
(0050) G:ES                     branch to level two.)
(0051) TS:S2
(0052) TS:G0,8
(0053) T: #A   +   #B   =
(0054) TS:G29,8
(0055) A:#D
(0056) TS:S1
(0057) J(D=C):TEST3
(0058) J(D<>C):LEV2

(0059) *TEST3                  (0059-0106 Placement test
(0060) C:I=RND(6)+4             three. If the answer
(0061) C:J=RND(6)+4             correct, present next
(0062) C:O=I+J+1                problem; otherwise,
```

```
G:ES                                   branch to level three.)
TS:S1;G12,0
T:FOLLOW THE STEPS
TS:G16,2
T:START
TS:G18,3
T:|
TS:G18,4
T:V
TS:G15,5
T:ADD #I +#J
TS:G18,6
T:|
TS:G18,7
T:V
TS:G12,8
T:IS THE ANSWER
TS:G12,9
T:EQUAL TO #O  ?
TS:G18,10
T:|
TS:G18,11
T:V
TS:G12,12
T:IF YES TYPE Y
TS:G12,13
T:IF NO TYPE N
TS:G18,14
T:|
TS:G18,15
T:V
TS:G12,16
T:PRESS RETURN
TS:G18,17
T:|
TS:G18,18
T:V
TS:G17,19
T:STOP
TS:G35,20
```

```
(0103) A:#G
(0104) M:N
(0105) JY:TEST4
(0106) N:LEV3
```

```
(0107) *TEST4
(0108) C:A=RND(5)+1
(0109) C:B=RND(5)
(0110) C:C=RND(4)+1
(0111) C:D=RND(6)
(0112) C:E=(A*10+B)+(C*10+D)
(0113) G:ES
(0114) TS:S2
(0115) TS:G10,6
(0116) T:    #A #B
(0117) TS:G10,8
(0118) T: + #C #D
(0119) TS:G10,10
(0120) T:______
(0121) TS:G16,13
(0122) A:#G
(0123) J(G=E):TEST5
(0124) L(G<>E):PART2,LEV4
(0125) TS:S1
```

(0107-0125 Placement test four. If the answer correct, present next problem; otherwise branch to level four.)

```
(0126) *TEST5
(0127) C:A=RND(5)+1
(0128) C:B=RND(5)
(0129) C:C=RND(4)+1
(0130) C:D=RND(6)
(0131) C:E=(A*10+B)+(C*10+D)
(0132) G:ES
(0133) TS:S2
(0134) TS:G0,6
(0135) T:  #A #B  + #C #D  =
(0136) TS:G24,6
(0137) A:#G
(0138) TS:S1
(0139) L(G<>E):PART2,LEV5
(0140) L(G=E):PART2,LEV6
```

(0126-0140 Placement test five. If the answer correct, present next problem; otherwise branch to level six.)

```
(0141) *LEV1                          (0141-0156 Present title
(0142) G:ES                            page and sound effects
(0143) TS:S2                           for level one.)
(0144) TS:F3
(0145) TS:G30,11;*10(AL ;WL)
(0146) S:12,10
(0147) TS:G14,0;*5(AL2$;WD;AL1$;WD;WU)
(0148) S:10,10
(0149) TS:G30,11;*8(AV ;WL)
(0150) S:8,10
(0151) TS:G18,23;*6(AL2$;WU;AL1$;WU;WD)
(0152) S:7,10
(0153) TS:G30,11;*6(AL ;WL)
(0154) S:5,10
(0155) TS:G30,11;*4(A1 ;WL)
(0156) W:1

(0157) *INITIAL                       (0157-0159 Set item (N)=0
(0158) C:N=0                           number of correct response
(0159) C:R=0                           (R) =0.)

(0160) *RANDOM                        (0160-0168 Generate two
(0161) G:ES                            single-digit numbers.)
(0162) C:N=N+1
(0163) J(N=5):JUMPL
(0164) C:W=0
(0165) C:Y=RND(4)+1
(0166) C:A=RND(7)+1
(0167) C:B=RND(7)+1
(0168) C:C=A+B

(0169) *QUES                          (0169-0199 Present the item;
(0170) G:ES                            accept the answer. If the
(0171) TS:S2                           answer correct, jump to
(0172) TS:F5                           label REINF. If the answer
(0173) TS:G0,5                         incorrect, execute label
(0174) TX:PICT                         WRONG.)
(0175) S:12,10
(0176) TS:*A(AL7$;WR;WR;D20)
```

```
(0177) TX:
(0178) TS:F3
(0179) TS:G31,5
(0180) T:  #A
(0181) TS:G0,7;F5
(0182) TX:PICT
(0183) S:10,10
(0184) TS:*B(AL7$;WR;WR;D20)
(0185) TX:
(0186) TS:G31,7;F3
(0187) T:+ #B
(0188) TS:G30,9
(0189) T:____
(0190) TS:T1
(0191) TS:F3
(0192) TS(C>9):G34,12
(0193) TS(C<=9):G35,12
(0194) A:#D
(0195) TS:S1
(0196) TE:
(0197) TE:TYPE A NUMBER, PLEASE.
(0198) JE:@A
(0199) J(D=C):REINF

(0200) *WRONG                      (0200-0214 If wrong<2,
(0201) G:V0,39,11,23                give hints then jump
(0202) G:ES                         to lable QUES to redo
(0203) TS:S2                        the item.)
(0204) TS:G30,20;F3
(0205) T: #C
(0206) TS:S1
(0207) TS:G26,23
(0208) TH:PRESS RETURN
(0209) AS:
(0210) G:V
(0211) TS:S2
(0212) T:
(0213) C:W=W+1
(0214) J(W<2):QUES
```

```
(0215) *NEXT                    (0215-0216 Jump to label
(0216) J:RANDOM                  RANDOM to generate
                                 numbers again.)

(0217) *JUMPL                   (0217-0219 If answer 4 items
(0218) J(R<4):LEV1               correctly, jump to level
(0219) J(R=4):LEV2               two; otherwise redo level
                                 one.)

(0220) *REINF                   (0220-0223 If the # of
(0221) C:R=R+1                   correct response equal to
(0222) J(R=Y):VREINF             the random #, give rein-
(0223) J(R<>Y):RANDOM            forcement; otherwise jump
                                 to label RANDOM.)

(0224) *VREINF                  (0224-0251 Present the
(0225) G:ES                      reinforcement; then jump
(0226) TX:MAXAPPLE               to label RANDOM to generate
(0227) TS:S1                     other numbers.)
(0228) TS:G24,6
(0229) T:   AB
(0230) TS:G24,7
(0231) T:CDEFGH[
(0232) TS:G24,8
(0233) T:IJKJKJ]
(0234) TS:G24,9
(0235) T:OPQPQP$
(0236) TS:G24,10
(0237) T:UVWXYZ#
(0238) TS:S2
(0239) TX:ASC
(0240) TS:G2,8
(0241) D:E$(5)
(0242) C:E$=" "
(0243) TS:*9(ABBC;WR;WL;AE$;WR;D10)
(0244) T:BC
(0245) S:50,10;50,10;50,10;50,10;50,10;50,10
(0246) TX:
(0247) TS:G12,16
(0248) T:GREAT!!!
(0249) TS:S1
(0250) W:1
(0251) J:RANDOM
```

```
(0252) *LEV2                        (0252-0267 Present title
(0253) G:ES                          page and sound effects
(0254) TS:S2                         for level two.)
(0255) TS:F3
(0256) TS:G30,11;*10(AL ;WL)
(0257) S:12,10
(0258) TS:G14,0;*5(AL2$;WD;AL1$;WD;WU)
(0259) S:10,10
(0260) TS:G30,11;*8(AV ;WL)
(0261) S:8,10
(0262) TS:G18,23;*6(AL2$;WU;AL1$;WU;WD)
(0263) S:7,10
(0264) TS:G30,11;*6(AL ;WL)
(0265) S:5,10
(0266) TS:G30,11;*4(A2 ;WL)
(0267) W:1

(0268) *INI2                        (0268-0270 Set item (N)=0
(0269) C:N=0                         number of correct response
(0270) C:R=0                         (R) = 0.)

(0271) *RAN2                        (0271-0278 Generate two
(0272) C:N=N+1                       single-digit numbers.)
(0273) J(N=5):JUMP3
(0274) C:W=0
(0275) C:Y=RND(4)+1
(0276) C:A=RND(9)+1
(0277) C:B=RND(9)+1
(0278) C:C=A+B

(0279) *QUE2                        (0279-0303 Present the item;
(0280) G:ES                          accept the answer. If the
(0281) TS:S2                         answer correct, jump to
(0282) D:L8$(5)                      label REIN2. If the answer
(0283) C:L8$="C"                     incorrect, execute label
(0284) TS:F2                         WRO2.)
(0285) S:50,10
(0286) TX:PICT
(0287) TS:G1,2
```

```
(0288) TS:*A(AL8$;WR;WR;D20)
(0289) S:32,10
(0290) TS:G1,4
(0291) TS:*B(AL8$;WR;WR;D20)
(0292) TX:
(0293) TS:F3
(0294) TS:G0,8
(0295) T: #A    +   #B    =
(0296) TS:G29,8
(0297) A:#D
(0298) TS:S1
(0299) TE:
(0300) TE:TYPE A NUMBER, PLEASE.
(0201) JE:@A
(0302) TS:S1
(0303) J(D=C):REIN2

(0304) *WRO2                          (0304-0318 If wrong<2
(0305) TS:S2                           give hints then jump
(0306) TS:F0                           to label QUE2 to redo
(0307) G:V29,39,7,23                   the item.)
(0308) G:ES
(0309) G:V
(0310) TS:F3
(0311) TS:G30,20
(0312) T: #C
(0313) TS:S1
(0314) TS:G26,23
(0315) TH:PRESS RETURN
(0316) AS:
(0317) C:W=W+1
(0318) J(W<2):QUE2

(0319) *NEX2                          (0319-0320 Jump to label
(0320) J:RAN2                          RAN2 to generate numbers
                                       again.)
(0321) *JUMP3                         (0321-0323 If answer 4 items
(0322) J(R<4):LEV2                     correctly, jump to level
(0323) J(R=4):LEV3                     three; otherwise redo level
                                       two.)
```

```
(0324) *REIN2                         (0324-0327 If the # of
(0325) C:R=R+1                         correct response equal to
(0326) J(R=Y):VREIN2                   the random #, five rein-
(0327) J(R<>Y):RAN2                    forcement; otherwise jump
                                       to label RAN2.)
(0328) *VREIN2                         (0328-0346 Present the
(0329) G:ES                             reinforcement; then jump
(0330) TS:S2;F3                         to label RAN2 to generate
(0331) TX:BASKETBALL                    other numbers.)
(0332) TS:G9,3;Aij;
(0333) :g13,5;A..QR/efSTU/gh..b/....b/....B
(0334) W:1
(0335) TS:G9,3;A.qr/.st;D0;WR;A.../.ij
(0336) TS:D0;WRD;a.z;D0
(0337) TS:D0;A../EF;WD;AEF/GH;D10;AIJ/KL;
       :D10;AMN/OP/kl
(0338) TS:Aef/gh/mn/op;D0;A12/34/../uv;
(0339)  :D5;Aef/gh;WD;WD
(0340) TS:*3(Amn/op;D9;a../kl;D9);Amn/op
(0341) TX:
(0342) S:8,20;11,20;8,20;8,20
       :;12,20;8,20;8,20;13,20
(0343) TS:G13,18
(0344) T:GOOD!!!
(0345) J:RAN2
(0346) TS:S1

(0347) *LEV3                          (0347-0362 Present title
(0348) G:ES                            page and sound effects

(0349) TS:S2                           for level three.)
(0350) TS:F3
(0351) TS:G30,11;*10(AL ;WL)
(0352) S:12,10
(0353) TS:G14,0;*5(AL2$;WD;AL1$;WD;WU)
(0354) S:10,10
(0355) TS:G30,11;*8(AV ;WL)
(0356) S:8,10
(0357) TS:G18,23;*6(AL2$;WU;AL1$;WU;WD)
(0358) S:7,10
```

```
(0359) TS:G30,11;*6(AL ;WL)
(0360) S:5,10
(0361) TS:G30,11;*4(A3 ;WL)
(0362) W:1

(0363) *INI3                          (0363-0365 Set item (N)=0
(0364) C:N=0                           # of correct response
(0365) C:R=0                           (R)=0.)

(0366) *RAN3                          (03666-0376 Generate two
(0367) C:N=N+1                         single-digit numbers.)
(0368) J(N=5):JUMP4
(0369) C:W=0
(0370) C:Y=RND(4)+1
(0371) C:I=RND(6)+4
(0372) C:J=RND(6)+4
(0373) C:K=I+J
(0374) C:O=K+1
(0375) C:P=K-1
(0376) C:Q=K+2

(0377) *FOLLO                         (0377-0460 Present item,
(0378) G:ES                            accept the answer, if
(0379) TS:S1;G12,0;F3                  the answer correct, jump
(0380) T:FOLLOW THE STEPS              label REIN3, if incorrect
(0381) S:32,10                         execute label WRO3.)
(0381) TX:MAXWELL
(0382) TS:G0,2
(0383) TS:*9(AM1$;AM2$;AM3$;WR)
(0384) TS:AM8$;D5;AM6$
(0385) TX:
(0386) TS:S1;G16,2
(0387) T:START
(0388) TS:G18,3
(0389) T:|
(0390) TS:G18,4
(0391) T:V
(0392) TS:G9,2
(0393) TX:MAXWELL
(0394) TS:AM6$;D5;AM7$
```

```
TX:
W:1
TS:G15,5
T:ADD #I +#J
TS:G18,6
T:|
TS:G18,7
T:V
TS:F0;G9,2
TX:MAXWELL
TS:AM7$
TX:
TS:F3;G8,9
TX:MAXWELL
TS:AM6$
TX:
TS:G12,8
T:IS THE ANSWER
TS:G12,9
T(N=1):EQUAL TO #O  ?
T(N=2):EQUAL TO #K  ?
T(N=3):EQUAL TO #P  ?
T(N=4):EQUAL TO #Q  ?
TS:G18,10
T:|
TS:G18,11
T:V
TS:G8,9
TX:MAXWELL
TS:AM6$;D5;AM7$
TX:
TS:G12,12
T:IF YES TYPE Y
W:1
TS:G12,13
T:IF NO TYPE N
W:1
TS:G18,14
T:|
TS:G18,15
```

```
(0435) T:V
(0436) TS:F0;G8,9
(0437) TX:MAXWELL
(0438) TS:AM7$
(0439) TX:
(0440) TS:F3;G8,16
(0441) TX:MAXWELL
(0442) TS:AM6$
(0443) TX:
(0444) TS:G12,16
(0445) T:PRESS RETURN
(0446) TS:G18,17
(0447) T:|
(0448) TS:G18,18
(0449) T:V
(0450) TS:G17,19
(0451) T:STOP
(0452) TS:G8,16
(0453) TX:MAXWELL
(0454) TS:AM7$;D60;AM4$
(0455) TX:
(0456) TS:G35,20
(0457) A:#G
(0458) M(N=2):Y
(0459) M(N<>2):N
(0460) JY:REIN3

(0461) *WRO3                     (0461-0465 If wrong<2,
(0462) TS:G30,20;S1               give hints then jump
(0463) T:TRY AGAIN                to label FOLLO to redo
(0464) C:W=W+1                    the item.)
(0465) J(W<2):FOLLO

(0466) *NEX3                     (0466-0467 Jump to label
(0467) J:RAN3                     RAN3 to generate numbers
                                  again.)
(0468) *JUMP4                    (0468-0470 If answer 4 items
(0469) J(R<4):LEV3                correctly, jump to level
(0470) L(R=4):PART2,LEV4          four; otherwise redo level
                                  three.)
```

```
(0471) *REIN3                          (0471-0474 If the #
(0472) C:R=R+1                          of correct response equal to
(0473) J(R=Y):VREIN3                    the random #, give rein-
(0474) J(R<>Y):RAN3                     forcement; otherwise jump to
                                        label RAN3.)
(0475) *VREIN3                         (0475-0497 Present the
(0476) G:ES                             reinforcement; then jump
(0477) TS:S2                            to label RAN3 to generate
(0478) TX:MAXWELL                       other numbers.)
(0479) TS:G0,11;*3(AM1$;AM2$;AM3$;WR;D5)
(0480) TS:AM8$;D5;AM9$
(0481) TX:
(0482) TS:S1
(0483) (0483) TX:BALLOON
(0484) TS:G9,0;A~===========================‘
(0485) TS:G8,1;A<                            >
(0486) TS:G7,2;A(
       :)
(0487) TS:G7,3;A|
       :|
(0488) TS:G7,4;A|          WONDERFUL!!!
       :|
(0489) TS:G7,5;A|
       :|
(0490) TS:G7,6;A[
       :]
(0491) TS:G8,7;A{                            }
(0492) TS:G9,8;A@__$________________________#
(0493) TS:G12,9;A^
(0494) TX:
(0495) S:44,20;0,30;39,10;38,10;39,10;40,30
       :;0,10;39,30
       :;0,20;43,20;0,30;44,20
(0496) J:RAN3
(0497) TS:S1


(0498) *LEV4                           (0498-0513 Present title
(0499) G:V                              page and sound effects
```

```
(0500) G:ES                               for level four.)
(0501) TS:S2
(0502) TS:F3
(0503) TS:G30,11;*10(AL ;WL)
(0504) S:12,10
(0505) TS:G14,0;*5(AL2$;WD;AL1$;WD;WU)
(0506) S:10,10
(0507) TS:G30,11;*8(AV ;WL)
(0508) S:8,10
(0509) TS:G18,23;*6(AL2$;WU;AL1$;WU;WD)
(0510) S:7,10
(0511) TS:G30,11;*6(AL ;WL)
(0512) S:5,10
(0513) TS:G30,11;*4(A4 ;WL)

(0514) *INI4                             (0514-0515 Use label
(0515) U:INI456                           INI456 to set item and
                                          # of correct response
                                          equal to 0.)
(0516) *RAN4                             (0516-0522 Generate two
(0517) C:N=N+1                            two-digit numbers.)
(0518) J(N=5):JUMP5
(0519) C:Y=RND(4)+1
(0520) U:RAN456
(0521) C:K=F+I
(0522) C:L=E+H

(0523) *LAF                              (0523-0525 Use graphic
(0524) G:ES                               LAFBIRD.)
(0525) GX:LAFBIRD!

(0526) *QUE4                             (0526-0547 Present the
(0527) S:32,10                            item. Accept the response.
(0528) G:V20,39,0,23                      if response correct jump
(0529) G:ES                               to label REIN4. If the
(0530) TS:S2                              response incorrect execute
(0531) TS:F3                              label WRO4.)
(0532) TS:G4,6
(0533) T:  #E #F
(0534) TS:G4,8
```

```
(0535) T:+ #H #I
(0536) TS:G3,10
(0537) T:______
(0538) TS:T1
(0539) TS:F3
(0540) TS:G8,13
(0541) A:#G4
(0542) TS:S1
(0543) TE:
(0544) TE:TYPE A NUMBER, PLEASE.
(0545) JE:@A
(0546) G:V
(0547) J(G4=J):REIN4

(0548) *WR04                    (0548-0585 If wrong<2,
(0549) G:V20,39,0,23             give hints then jump
(0550) G:ES                      to label QUE4 to redo
(0551) TS:F3;S1                  the item.)
(0552) TS:G0,0
(0553) S:32,10
(0554) T:ADD THE ONES FIRST
(0555) TS:S2
(0556) TS:G6,6
(0557) T:    #F
(0558) TS:G6,8
(0559) T: +  #I
(0560) TS:G6,10
(0561) T: _____
(0562) W:1
(0563) TS:G6,13
(0564) T:    #K
(0565) W:2
(0566) TS:F3;S1
(0567) TS:G0,2
(0568) S:32,10
(0569) T:THEN ADD THE TENS
(0570) TS:S2;G2,6
(0571) T:     #E
(0572) TS:G6,8
(0573) T: + #H
```

```
(0574) W:1
(0575) TS:G2,13
(0576) T:      #L
(0577) TS:F3
(0578) TS:G6,20
(0579) TS:S1
(0580) TH:PRESS RETURN
(0581) AS:
(0582) G:V
(0583) T:
(0584) C:W=W+1
(0585) J(W<2):QUE4

(0586) *NEX3                    (0586-0587 Jump to label
(0587) J:RAN4                    RAN4 to generate numbers
                                 again.)

(0588) *JUMP5                   (0588-0590 If answer 4 items
(0589) J(R<4):LEV4               correctly, jump to label
(0590) J(R=4):LEV5               LEV5; otherwise redo level
                                 four.)

(0591) *REIN4                    (0591-0594 If the # of
(0592) C:R=R+1                    correct response equal to
(0593) J(R=Y):VREIN4              the random #, give rein-
(0594) J(R<>Y):RAN4               forcement; otherwise jump
                                  to label RAN4.)

(0595) *VREIN4                   (0595-0631 Present the
(0596) G:ES                       reinforcement; then jump
(0597) TS:S1;F3                   label RAN4 to generate
(0598) D:S$(5)                    other numbers.)
(0599) C:S$="NO/PQ"
(0600) TX:PICT
(0601) S:8,20
(0602) TS:G30,8;AS$;D10
(0603) S:8,20
(0604) TS:F3;G38,10;AS$;D10
(0605) S:15,20
(0606) TS:F3;G10,6;AS$;D10
(0607) S:15,20
(0608) TS:G2,5;AS$;D10;
(0609) S:17,20
```

```
(0610) TS:G22,1;AS$;D10
(0611) S:17,20
(0612) TS:G15,4;AS$;D10
(0613) S:15,40
(0614) TS:M3;G38,10;*2(AS$;D10)
(0615) S:13,20
(0616) TS:G2,5;*2(AS$;D10)
(0617) S:13,20
(0618) TS:G30,8;*2(AS$;D10)
(0619) S:12,20
(0620) TS:G10,6;*2(AS$;D10)
(0621) S:12,20
(0622) TS:G22,1;*2(AS$;D10)
(0623) S:11,20
(0624) TS:G15,4;*2(AS$;D10)
(0625) S:11,20;8,40
(0626) TX:
(0627) TS:M1;G10,17;S2;F1
(0628) T:EXCELLENT!!!
(0629) TS:S1
(0630) W:1
(0631) J:RAN4

(0632) *LEV5                              (0632-0646 Present title
(0633) G:ES                                page and sound effects
(0634) TS:S2                               for level five.)
(0635) TS:F3
(0636) TS:G30,11;*10(AL ;WL)
(0637) S:12,10
(0638) TS:G14,0;*5(AL2$;WD;AL1$;WD;WU)
(0639) S:10,10
(0640) TS:G30,11;*8(AV ;WL)
(0641) S:8,10
(0642) TS:G18,23;*6(AL2$;WU;AL1$;WU;WD)
(0643) S:7,10
(0644) TS:G30,11;*6(AL ;WL)
(0645) S:5,10
(0646) TS:G30,11;*4(A5 ;WL)

(0647) *INI5                              (0647-0648 Use label
```

```
(0648) U:INI456
```

INI456 to set item and # of correct responses equal to 0.)

```
(0649) *RAN5
(0650) C:N=N+1
(0651) J(N=5):JUMP6
(0652) C:Y=RND(4)+1
(0653) U:RAN456
```

(0649-0653 Use label RAN456 to generate two two-digit numbers.)

```
(0654) *CAT
(0655) D:T1$(20);T2$(20);T3$(20)
(0656) C:T1$=" 12WX3/ SMAGC/ 678"
(0657) C:T2$=" BDWX3/ SMAGC/ 678"
(0658) C:T3$="TERRIFIC!!!   "
(0659) TX:CAT
(0660) G:ES
(0661) TS:S2
(0662) TS:G3,8;F5
(0663) TS:AT1$
(0664) TX:
(0665) TS:S1
```

(0654-0665 Reinforcement for level five.)

```
(0666) *QUE5
(0667) S:32,10
(0668) G:V15,39,0,23
(0669) TS:S2
(0670) G:ES
(0671) TS:F3
(0672) TS:G0,6
(0673) T:  #E #F +#H #I =
(0674) TS:G17,6
(0675) A:#G4
(0676) TS:S1
(0677) TE:
(0678) TE:TYPE A NUMBER, PLEASE.
(0679) JE:@A
(0680) G:V
(0681) J(G4=J):REIN5
```

(0666-0681 Present the item; accept the response. If response correct jump to label REIN5. If response incorrect execute label WRO5.)

```
(0682) *WRO5                            (0682-0707 If wrong<2,
(0683) G:V15,39,0,23                     give hints then jump
(0684) TS:G17,6;F0;S2                    to label QUE5 to redo
(0685) T:#G4                             the item.)
(0686) G:V
(0687) TS:F3
(0688) G:V20,39,12,23
(0689) G:ES
(0690) TS:S2
(0691) TS:F3;S2
(0692) TS:G4,0
(0693) S:32,10
(0694) T:  #E #F
(0695) TS:G4,4
(0696) T:+ #H #I
(0697) TS:G3,6
(0698) T:______
(0699) TS:G7,10
(0700) TS:S1
(0701) TH:PRESS RETURN
(0702) AS:
(0703) G:V
(0704) C:W=W+1
(0705) J(W<2):QUE5
(0706) *NEX5
(0707) J:RAN5

(0708) *JUMP6                           (0708-0710 If answer 4 items
(0709) J(R<4):LEV5                       correctly, jump to level
(0710) J(R=4):LEV6                       six; otherwise redo level
                                         five.)
(0711) *REIN5                           (0711-0714 If the # of
(0712) C:R=R+1                           correct response equal to
(0713) J(R=Y):VREIN5                     the random #, give rein-
(0714) J(R<>Y):RAN5                      forcement; otherwise jump
                                         to label RAN5.)
(0715) *VREIN5                          (0715-0735 Present the
(0716) G:ES                              reinforcement; then jump
(0717) D:T1$(20);T2$(20);T3$(20)         to label RAN5 to generate
(0718) C:T1$=" 12WX3/ SMAGC/ 678"        other numbers.)
```

```
(0719) C:T2$=" BDWX3/ SMAGC/ 678"
(0720) C:T3$="TERRIFIC!!!   "
(0721) TS:G2,8;F3
(0722) TS:*2(AT1$;D10;AT2$;D10)
(0723) TX:
(0724) S:32,20;44,20
(0725) TS:G34,10;F5
(0726) TS:*3(AT3$;D30;WL)
(0727) TX:CAT
(0728) TS:G2,8;F3
(0729) TS:*2(AT1$;D10;AT2$;D10)
(0730) TX:
(0731) S:32,20;44,20
(0732) TS:G23,10;F5
(0733) TS:*4(AT3$;D30;WL)
(0734) J:RAN5
(0735) TS:S1

(0736) *LEV6                          (0736-0751 Present title
(0737) G:ES                            page and sound effects
(0738) TS:S2                           for level six.)
(0739) TS:F3
(0740) TS:G30,11;*10(AL ;WL)
(0741) S:12,10
(0742) TS:G14,0;*5(AL2$;WD;AL1$;WD;WU)
(0743) S:10,10
(0744) TS:G30,11;*8(AV ;WL)
(0745) S:8,10
(0746) TS:G18,23;*6(AL2$;WU;AL1$;WU;WD)
(0747) S:7,10
(0748) TS:G30,11;*6(AL ;WL)
(0749) S:5,10
(0750) TS:G30,11;*4(A6 ;WL)
(0751) TS:S1

(0752) *INI61                         (0752-0753 Use label
(0753) U:INI456                        INI456 to set item and #
                                       of correct response equal
                                       to 0.)
(0754) *RAN6                          (0754-0761 Generate two
```

```
(0755) U:RAN456                          two-digit numbers.)
(0756) U:RANM
(0757) J(J=T):INI61
(0758) C:A=(E*10+F)+(P*10+Q)
(0759) C:B=(H*10+I)+(M*10+S)
(0760) C:C=(H*10+I)+(P*10+Q)
(0761) C:W=0

(0762) *UCHA1                           (0762-0764 Use label CHART
(0763) U:CHART                           to draw chart.)
(0764) C:Y=RND(4)+1

(0765) *QUE61                           (0765-0795 Present the
(0766) G:V0,39,16,23                     first item for level six.
(0767) G:ES                              If answer correct or
(0768) G:V                               wrong<2, jump to label
(0769) TS:G2,11;S1;F3                    INI62.)
(0770) T:1. HOW MANY
(0771) TX:CAR
(0772) TS:G13,10
(0773) TS:A/   ABW/ CDEFGHI/ JKLMNOP
(0774) TX:
(0775) TS:G22,11
(0776) T:DID JOHN AND LISA
(0777) TS:G5,15
(0778) T:COUNT TOGETHER?
(0779) TS:M3
(0780) TS:G26,11
(0781) TS:*2(AP1$;D30)
(0782) TS:G35,11
(0783) TS:*2(AP3$;D30)
(0784) TS:G26,11
(0785) TS:*2(AP1$;D30)
(0786) TS:G35,11
(0787) TS:*2(AP3$;D30)
(0788) TS:M1
(0789) TS:G2,17
(0790) A:#D
(0791) TE:TYPE A NUMBER, PLEASE
(0792) JE:@A
```

```
(0793) C:W=W+1
(0794) J(D=A):INI62
(0795) J(W>=2):INI62

(0796) *WR061                        (0796-0811 If the answer
(0797) G:V0,39,16,23                  incorrect, present the
(0798) G:ES                           hints.)
(0799) G:V
(0800) TS:G2,17;S1;F3
(0801) T:HINTS:
(0802) TS:G2,18
(0803) T:JOHN COUNTED  #E #F  CARS
(0804) TS:G2,19
(0805) T:LISA COUNTED  #P #Q  CARS
(0806) TS:G2,20
(0807) T:HOW MANY IN ALL?
(0808) TS:G14,23
(0809) TH:PRESS RETURN TO TRY AGAIN
(0810) AS:
(0811) J(W<2):QUE61

(0812) *INI62                        (0812-0815 If it is time
(0813) C(D=A):R=R+1                   to reinforce the user,
(0814) U(R=Y):SREIN                   use label SREIN; other-
(0815) J(R<>Y):UCHA2                  wise jump to label UCHA2.)

(0816) *UCHA2                        (0816-0819 Use label
(0817) U:CHART                        CHART. Generate a number
(0818) C:Y=RND(4)+1                   called Y. Set wrong=0.)
(0819) C:W=0
(0820) *QUE62                        (0820-0850 Present the
(0821) G:V0,39,16,23                  second item of level six.
(0822) G:ES                           If answer correct or
(0823) G:V                            wrong<2, jump to label
(0824) TS:G2,11;S1;F3                 INI63.)
(0825) T:2. HOW MANY
(0826) TX:CAR
(0827) TS:G13,10
(0828) TS:A/   ABW/ CDEFGHI/ JKLMNOP
(0829) TX:
```

```
(0830) TS:G22,11
(0831) T:DID DAVE AND MARY
(0832) TS:G5,15
(0833) T:COUNT TOGETHER?
(0834) TS:M3
(0835) TS:G26,11
(0836) TS:*2(AP2$;D30)
(0837) TS:G35,11
(0838) TS:*2(AP4$;D30)
(0839) TS:G26,11
(0840) TS:*2(AP2$;D30)
(0841) TS:G35,11
(0842) TS:*2(AP4$;D30)
(0843) TS:M1
(0844) TS:G2,17
(0845) A:#D
(0846) TE:TYPE A NUMBER, PLEASE
(0847) JE:@A
(0848) J(D=B):INI63
(0849) C:W=W+1
(0850) J(W=2):INI63

(0851) *WR062                        (0851-0866 If the answer
(0852) G:V0,39,16,23                  incorrect, present the
(0853) G:ES                           hints.)
(0854) G:V
(0855) TS:G2,17;S1;F3
(0856) T:HINTS:
(0857) TS:G2,18
(0858) T:DAVE COUNTED #H #I  CARS
(0859) TS:G2,19
(0860) COUNTED #M #S  CARS
(0861) TS:G2,20
(0862) T:HOW MANY IN ALL?
(0863) TS:G14,23
(0864) TH:PRESS RETURN TO TRY AGAIN
(0865) AS:
(0866) J(W<2):QUE62

(0867) *INI63                        (0867-0870 If it is time
```

```
(0868) C(D=B):R=R+1                 to reinforce the user,
(0869) U(R=Y):SREIN                 use label SREIN; otherwise
(0870) T(R<>Y):UCHA3                jump to label UCHA3.)

(0871) *UCHA3                       (0871-0874 Use label
(0872) U:CHART                       CHART; generate a number
(0873) C:Y=RND(4)+1                  called Y; and set wrong=0.)
(0874) C:W=0

(0875) *QUE63                       (0875-0905 Present the
(0876) G:V0,39,16,23                 third item of level six.
(0877) G:ES                          If the answer correct or
(0878) G:V                           wrong<2, jump to label
(0879) TS:G2,11;S1;F3                INI64.)
(0880) T:3. HOW MANY
(0881) TX:CAR
(0882) TS:G13,10
(0883) TS:A/   ABW/ CDEFGHI/ JKLMNOP
(0884) TX:
(0885) TS:G22,11
(0886) T:DID LISA AND DAVE
(0887) TS:G5,15
(0888) T:COUNT TOGETHER?
(0889) TS:M3
(0890) TS:G26,11
(0891) TS:*2(AP3$;D30)
(0892) TS:G35,11
(0893) TS:*2(AP2$;D30)
(0894) TS:G26,11
(0895) TS:*2(AP3$;D30)
(0896) TS:G35,11
(0897) TS:*2(AP2$;D30)
(0898) TS:M1
(0899) TS:G2,17
(0900) A:#D
(0901) TE:TYPE A NUMBER, PLEASE
(0902) JE:@A
(0903) J(D=C):INI64
(0904) C:W=W+1
(0905) J(W=2):INI64
```

```
(0906) *WR063
(0907) G:V0,39,16,23
(0908) G:ES
(0909) G:V
(0910) TS:G2,17;S1;F3
(0911) T:HINTS:
(0912) TS:G2,18
(0913) T:LISA COUNTED #P #Q  CARS
(0914) TS:G2,19
(0915) T:DAVE COUNTED #H #I  CARS
(0916) TS:G2,20
(0917) T:HOW MANY IN ALL?
(0918) TS:G14,23
(0919) TH:PRESS RETURN TO TRY AGAIN
(0920) AS:
(0921) J(W<2):QUE63
```

(0906-0921 If the answer incorrect, present hints.)

```
(0922) *INI64
(0923) C(D=C):R=R+1
(0924) U(R=Y):SREIN
(0925) J(R<>Y):UCHA4
```

(0922-0925 If it is time to reinforce the user, use label SREIN; otherwise jump to label UCHA4.)

```
(0926) *UCHA4
(0927) U:CHART
(0928) C:Y=RND(4)+1
(0929) C:W=0
```

(0926-0929 Use label CHART; generate a # called Y; and set wrong=0.)

```
(0930) *QUE64
(0931) G:V0,39,11,23
(0932) G:ES
(0933) G:V
(0934) TS:G2,11;S1;F3
(0935) T:4. WHO COUNTED MORE
(0936) TX:CAR
(0937) TS:G21,10
(0938) TS:A/   ABW/ CDEFGHI/ JKLMNOP
(0939) TX:
(0940) TS:G5,15
(0941) T:THE GIRLS OR THE BOYS ?
```

(0930-0960 Present the fourth item of level six. If answer correct or wrong<2, jump to label REIN6; otherwise execute label WR064.)

```
(0942) TS:M3
(0943) TS:G9,15
(0944) TS:*2(AP5$;D30)
(0945) TS:G22,15
(0946) TS:*2(AP6$;D30)
(0947) TS:G9,15
(0948) TS:*2(AP5$;D30)
(0949) TS:G22,15
(0950) TS:*2(AP6$;D30)
(0951) TS:M1
(0952) TS:G5,17
(0953) T:TYPE G FOR GIRLS OR B FOR BOYS
(0954) TS:G2,19
(0955) A:
(0956) M(T>J):G!GIR!GIRL!GIRLS
(0957) M(T<J):B!BO!BOY!BOYS
(0958) JY:REIN6
(0959) C:W=W+1
(0960) J(W=2):LEV6

(0961) *WR064                        (0961-0978 If the answer
(0962) G:V0,39,16,23                  incorrect, present hints.)
(0963) G:ES
(0964) G:V
(0965) TS:G2,17;S1;F3
(0966) T:HINTS:
(0967) TS:G2,18
(0968) T:GIRLS COUNTED #P #Q  + #M #S  =
(0969) : #T  CARS
(0970) TS:G2,19
(0971) T:BOYS COUNTED #E #F  + #H #I  =
(0972) :#J  CARS
(0973) TS:G2,20
(0974) T:WHICH SUM IS GREATER ?
(0975) TS:G14,23
(0976) TH:PRESS RETURN TO TRY AGAIN
(0977) AS:
(0978) J(W<2):QUE64

(0979) *REIN6                        (0979-0986 If it is time
```

```
(0980) C:R=R+1
(0981) G:ES
(0982) TS:G13,10;S2
(0983) U(R=Y):SREIN
(0984) TS:S1
(0985) J(R<>4):LEV6
(0986) J(R=4):COMP
```

to reinforce the user, use label SREIN; otherwise jump to label COMP.)

```
(0986) *COMP
(0987) G:ES
(0988) TS:S2;G2,4;F1
(0989) T:*****************
(0990) TS:G2,6
(0991) T:*               *
(0992) TS:G2,8
(0993) T:*     AWARD     *
(0994) TS:G2,10
(0995) T:*               *
(0996) TS:G2,12
(0997) T:*****************
(0998) TS:S1
(0999) TS:G12,16;F3
(1000) T:As I can see,
(1001) TS:G9,18
(1002) T:I am proud of you,
(1003) TS:G9,20
(1004) T:You can add now!!!
(1005) W:1
(1006) J:STOP
```

(0986-1006 If the user complete the level six, display the congratulation frame and jump to label STOP.)

```
(1007) *INI456
(1008) C:N=0
(1009) C:R=0
(1010) E:
```

(1007-1010 Set item=0; number of correct response=0.)

```
(1011) *RANM
(1012) C:P=RND(4)+1
(1013) C:Q=RND(5)
(1014) C:M=RND(4)+1
(1015) C:S=RND(6)
(1016) C:T=(P*10+Q)+(M*10+S)
```

(1011-1016 Compute the correct answer.)

```
(1016) E:

(1017) *RAN456                              (1017-1024 Generate
(1018) C:W=0                                 random numbers.)
(1019) C:E=RND(5)+1
(1020) C:F=RND(5)
(1021) C:H=RND(4)+1
(1022) C:I=RND(6)
(1023) C:J=(E*10+F)+(H*10+I)
(1024) E:

(1025) *CHART                               (1025-1066 Draw a chart
(1026) G:ES                                  for level six.)
(1027) TS:F3;S1
(1028) T:USE THE CHART. SOLVE THE PROBLEM.
(1029) G:M8,450
(1030) G:D551,450
(1031) G:D551,300
(1032) G:D8,300
(1033) G:D8,450
(1034) G:M8,375
(1035) G:D551,375
(1036) TS:G3,4
(1037) T:NAME
(1038) TS:G2,7
(1039) T:CARS
(1040) TS:G2,8
(1041) T:COUNTED
(1042) G:M171,450
(1043) G:D171,300
(1044) TS:G14,4
(1045) T:JOHN
(1046) G:M266,450
(1047) G:D266,300
(1048) TS:G21,4
(1049) T:DAVE
(1050) G:M361,450
(1051) G:D361,300
(1052) TS:G28,4
(1053) T:LISA
```

```
(1054) G:M456,450
(1055) G:D456,300
(1056) TS:G34,4
(1057) T:MARY
(1058) TS:G14,8
(1059) T:#E #F
(1060) TS:G21,8
(1061) T:#H #I
(1062) TS:G28,8
(1063) T:#P #Q
(1064) TS:G34,8
(1065) T:#M #S
(1066) E:

(1067) *SREIN                              (1067-1077 Present
(1068) G:ES                                 reinforcement to
(1069) TX:CAR                               the user.)
(1070) TS:S2;G0,8;F3
(1071) TS:*7(A/   ABW/ CDEFGHI/ JKLMNOP;WR;D20)
(1072) TX:
(1073) S:32,10;36,10;39,10;44,10
(1074) TS:G14,18;F2
(1075) T:SUPER!!!
(1076) TS:S1
(1077) E:

(1078) *STOP                               (1078-1096 Say bye to
(1079) G:ES                                 the user then exit.)
(1080) TS:F2;S2
(1081) T:
(1082) T:
(1083) T:
(1084) TX:PICT
(1085) T:C C C C C C C C C C
(1086) T:
(1087) T:C                  C
(1088) TS:F3
(1089) T:        B Y E
(1090) TS:F2
(1091) T:C                  C
```

```
(1092) T:
(1093) T:C C C C C C C C C C
(1094) TX:
(1095) T:
(1096) TS:F3;S1
```

APPENDIX B. HUMAN SUBJECTS FORM

Information for Review of Research Involving Human Subjects
Iowa State University
(Please type and use the attached instructions for completing this form)

1. Title of Project The Effects of Different Sys 114 of Positive Reinforcement on Computer-Based Learning

2. I agree to provide the proper surveillance of this project to insure that the rights and welfare of the human subjects are protected. I will report any adverse reactions to the committee. Additions to or changes in research procedures after the project has been approved will be submitted to the committee for review. I agree to request renewal of approval for any project continuing more than one year.

Yang M. Tsai — Typed Name of Principal Investigator
9/10/91 — Date
Yang Tsai — Signature of Principal Investigator

Curriculum and Instruction — Department
645 Pammel Ct. Ames, IA 50010 — Campus Address
296-7893 — Campus Telephone

3. Signatures of other investigators — Date — Relationship to Principal Investigator

Carl D. Thorpe — 9-9-91 — Major Professor

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4. Principal Investigator(s) (check all that apply)
☐ Faculty ☐ Staff ☒ Graduate Student ☐ Undergraduate Student

5. Project (check all that apply)
☐ Research ☒ Thesis or dissertation ☐ Class project ☐ Independent Study (490, 590, Honors project)

6. Number of subjects (complete all that apply)
___ # Adults, non-students ___ # ISU student 45 # minors under 14 ___ other (explain)
___ # minors 14 - 17

7. Brief description of proposed research involving human subjects: (See instructions, Item 7. Use an additional page if needed.)

The problem addressed in this study is to inquire into the effectiveness of three selected hierarchies of positive reinforcement stimuli coupled with different presentation schedules on computer-based learning on the concepts of addition. To collect the necessary data for this research, nine computer programs with identical instructional contents but with different reinforcement systems will be developed. Second-graders in an Ames elementary school will be chosen as the sample. These students will be randomly assigned to one of the nine groups. A pretest and a posttest will be given before and after the course of the experiment.

(Also see the attached Abstract)

(Please do not send research, thesis, or dissertation proposals.)

8. Informed Consent:
☒ Signed informed consent will be obtained. (Attach a copy of your form.)
☐ Modified informed consent will be obtained. (See instructions, item 8.)
☐ Not applicable to this project.

9. Confidentiality of Data: Describe below the methods to be used to ensure the confidentiality of data obtained. (See instructions, item 9.)

Each student's identity will be kept confidential; only group analyses of the data will be reported.

10. What risks or discomfort will be part of the study? Will subjects in the research be placed at risk or incur discomfort? Describe any risks to the subjects and precautions that will be taken to minimize them. (The concept of risk goes beyond physical risk and includes risks to subjects' dignity and self-respect as well as psychological or emotional risk. See instructions, item 10.)

Since in the research, we give only positive reinforcements to the subjects, the chance of discomfort is little.

11. CHECK ALL of the following that apply to your research:

- ☐ A. Medical clearance necessary before subjects can participate
- ☐ B. Samples (Blood, tissue, etc.) from subjects
- ☐ C. Administration of substances (foods, drugs, etc.) to subjects
- ☐ D. Physical exercise or conditioning for subjects
- ☐ E. Deception of subjects
- ☒ F. Subjects under 14 years of age and/or ☐ Subjects 14 - 17 years of age
- ☐ G. Subjects in institutions (nursing homes, prisons, etc.)
- ☐ H. Research must be approved by another institution or agency (Attach letters of approval)

If you checked any of the items in 11, please complete the following in the space below (include any attachments):

Items A - D Describe the procedures and note the safety precautions being taken.

Item E Describe how subjects will be deceived; justify the deception; indicate the debriefing procedure, including the timing and information to be presented to subjects.

Item F For subjects under the age of 14, indicate how informed consent from parents or legally authorized representatives as well as from subjects will be obtained.

Items G & H Specify the agency or institution that must approve the project. If subjects in any outside agency or institution are involved, approval must be obtained prior to beginning the research, and the letter of approval should be filed.

Last Name of Principal Investigator Tsai

Checklist for Attachments and Time Schedule

The following are attached (please check):

12. [X] Letter or written statement to subjects indicating clearly:
   a) purpose of the research
   b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see Item 17)
   c) an estimate of time needed for participation in the research and the place
   d) if applicable, location of the research activity
   e) how you will ensure confidentiality
   f) in a longitudinal study, note when and how you will contact subjects later
   g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. [X] Consent form (if applicable)

14. [ ] Letter of approval for research from cooperating organizations or institutions (if applicable)
Will be attached after I get the assignment of school from the Ames District.

15. [X] Data-gathering instruments

16. Anticipated dates for contact with subjects:

First Contact: 10/7/91 (Month / Day / Year)

Last Contact: 12/20/91 (Month / Day / Year)

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

8/31/92 (Month / Day / Year)

18. Signature of Departmental Executive Officer: [signature] Date: 9-9-91 Department or Administrative Unit: Curriculum and Instruction

19. Decision of the University Human Subjects Review Committee:

X Project Approved ___ Project Not Approved ___ No Action Required

Patricia M. Keith — Name of Committee Chairperson

9-24-91 — Date

P M Keith — Signature of Committee Chairperson

GC:1/90

APPENDIX C. PRINCIPAL PERMISION

GILBERT
COMMUNITY SCHOOLS
QUALITY EDUCATION FOR ALL

GILBERT, IOWA 50105

SUPERINTENDENT 515/232-3740 • SECONDARY 232-3738 • ELEMENTARY 232-3744

10-4-91

To Whom It May Concern:

Yang Tsai has permission to conduct graduate research at Gilbert Elementary School with the 2nd graders.

David Ashby

Elementary Principal

608 062

APPENDIX D. LETTER TO PARENTS

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

College of Education
Department of Curriculum and Instructi
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Ames, Iowa 50011-3190
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Oct. 4, 1991

Dear Parents:

As a graduate student working toward a Doctoral degree in Curriculum and Instruction under the direction of Dr. Ann Thompson, I am conducting a study concerning the effects of different systems of positive reinforcement on computer-based learning in helping young children learn mathematics. In order to make the results of this study as useful as possible to children and teachers, it is very important for each child in the class to participate in the study. Therefore, I would appreciate receiving your permission to involve your child in this study.

In the study, each child will run a computer program that is developed to reinforce arithmetic concepts of addition. Each child will spend a total of approximately 90 minutes working with the program; this time will be divided into three 30-minute parts. Also, a pretest on addition and a similar posttest will be given.

I would like to use the resulting data in my dissertation work. Meanwhile, the participation in this project is voluntary, and you may withdraw your child at any time. Each child's identity will be kept confidential; only group analyses of the data will be reported. At the conclusion of the study, I will provide the teachers with a summary of the results of the study; at your request, I will gladly also provide a summary of the results to you.

If you agree to allow your child to participate in this study, please sign the attached form and return it to your child's teacher by Oct. 7. If you have any questions about the study or your child's participation, please call me at 296-7893 or Dr. Ann Thompson at 294-5287.

Sincerely,

Yang Tsai

Yang Tsai
Graduate Student

Ann D. Thompson

Ann Thompson
Professor and Chair

Parental Permission for Partici[illegible]on in Tsai/Thompson Research

______ I am willing to let my child, ____________________________,
(child's/children's name)

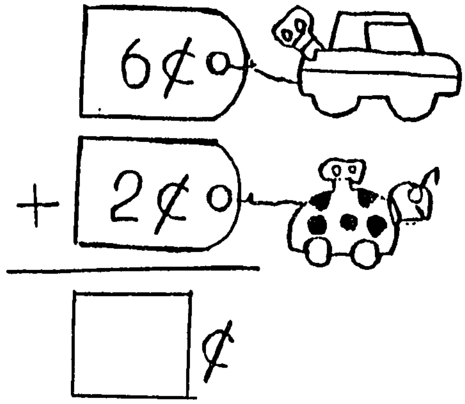
participate in this study.

Signature:____________________________ Date:________________

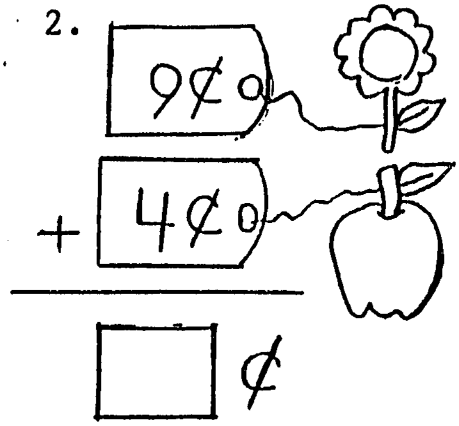
APPENDIX E. PRETEST

PRETEST

1.



2.



3. Circle sums of 10

3 + 7
5 + 9
7 + 3
4 + 6
2 + 7
8 + 2

4. Circle sums of 12

6 + 6
8 + 3
5 + 7
6 + 9
7 + 6
8 + 4

The weather chart.

Weather				
Number of days	7	8	6	9

Read the chart. write the number.

5. There were _____ sunny days.

   There were _____ cloudy days.

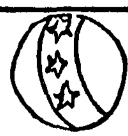
   How many days altogether were sunny or cloudy?

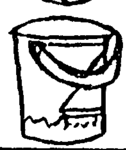
   _____ days.

6. How many days in all were rainy or cloudy?

   _____ days.

7. How many are there in all?

13 

42 

$$\begin{array}{r} 13 \\ +42 \\ \hline \end{array}$$

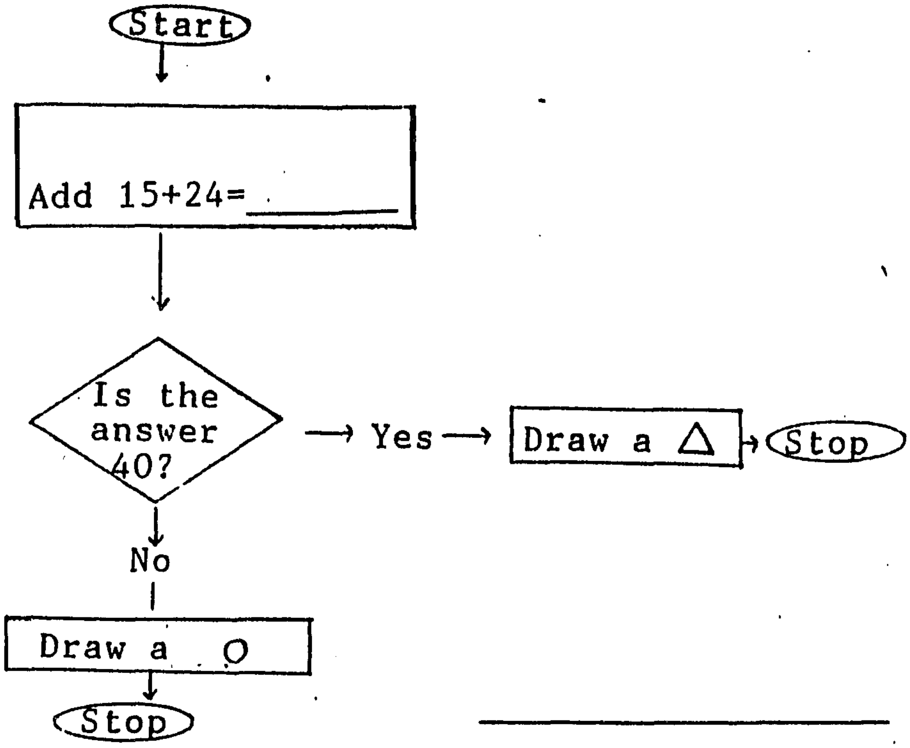
8. How many are there altogether?

25 

33 

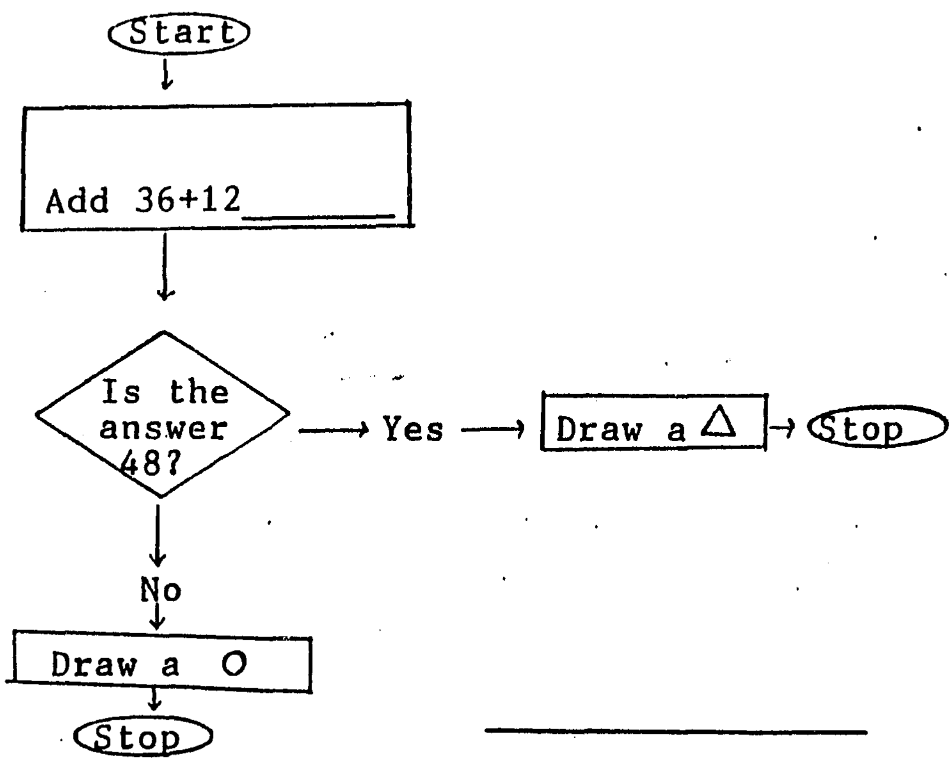
$$\begin{array}{r} 25 \\ +33 \\ \hline \end{array}$$

9. Follow the steps.



____

10. Follow the steps.



____

Name	Jeff	Mark	Rose	Jane
Book Read	22	24	33	15

Read the table. Write the number.

11. Jeff read _____ books.

Rose read _____ books.

How many books did they read together?

_____________ books.

12. How many books did Mark and Jane read in all?

_____________ books.

13. Who read more books, the boys or the girls?

____

APPENDIX F. POSTTEST

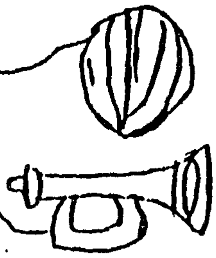
POSTTEST

1.

4¢

+ 5¢

☐ ¢

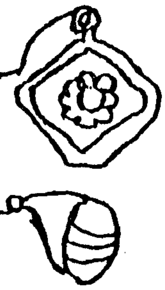


2.

7¢

+ 6¢

☐ ¢



3. Circle sums of 11

5 + 6
4 + 9
3 + 8
7 + 4
8 + 5
2 + 7

4. Circle sums of 10

2 + 8
4 + 6
6 + 7
8 + 2
6 + 3
5 + 5

The weather chart.

Weather				
Number of days	9	7	8	6

Read the chart. Write the number.

5. There were _____ snowy days.

   There were _____ rainy days.

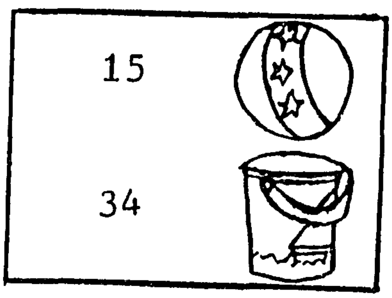
   How many days altogether were snowy or rainy?

   _____ days.

6. How many days in all were sunny or snowy?

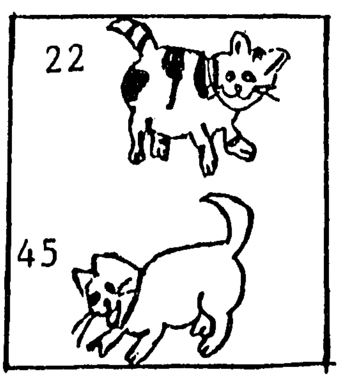
   _____ days.

7. How many are there in all?



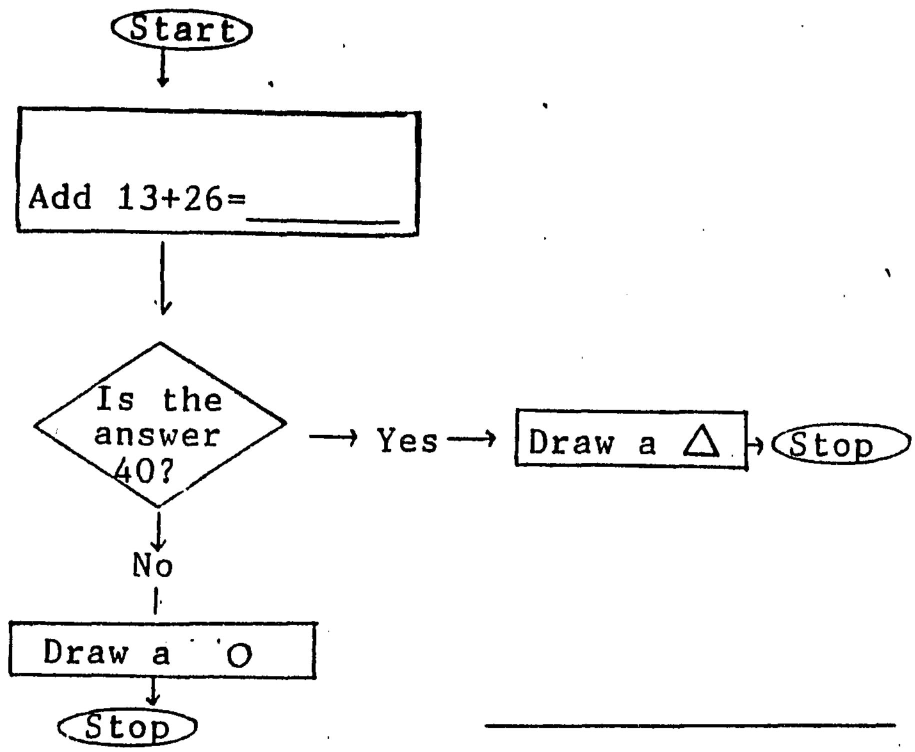
$$\begin{array}{r} 15 \\ +\,34 \\ \hline \end{array}$$

8. How many are there altogether?

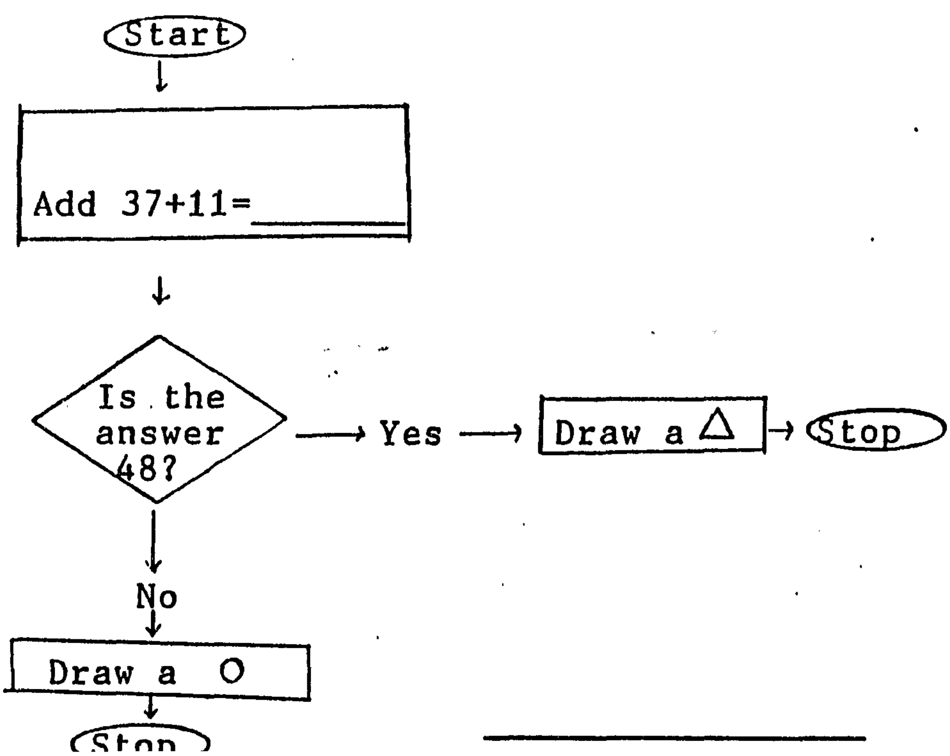


$$\begin{array}{r} 22 \\ +\,45 \\ \hline \end{array}$$

9. Follow the steps.



10. Follow the steps.



Name	Sue	Lisa	Bob	Mike
Car counted	43	35	32	50

Read the table. Write the number.

11. Lisa counted _____ cars.

    Bob counted _____ cars.

    How many cars did they count together?

    ____________ cars.

12. How many cars did Sue and Mike count in all?

    ____________ cars.

13. Who counted more cars, the boys or the girls?

    ____